dietary nutrients to be metabolized), which would require the central thermoregulatory mechanisms to activate ST (and insulative defenses such as feather erection) to provide sufficient heat to achieve the nocturnal setpoint in Tb which, we have argued above, would be higher after the cellulose loads because of the volumetric difference. Additional considerations concerning the thermogenic efficiency of pectoral shivering when pigons are in various feeding conditions are discussed elsewhere [11].

The present findings support the idea that gastrointestinal volume participates in "setting" the pigeon's nocturnal Tb. Our results join those of Reinertsen and Bech with pigeons [8], and others with mammals [7, 15], in encouraging study of the pathways and mechanisms involved when gastrointestinal and thermoregulatory systems interact.

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Beryllium-7 and Ozone Correlations in Surface Atmosphere

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Beryllium-7 (^{7}Be, $t_{1/2}$ = 53 days) produced in nature only by spallation processes in the stratosphere and the upper troposphere [1], can be regarded as a tracer for studying atmospheric exchange and transport processes. The surface air concentration of ^{7}Be as measured in Vienna shows the typical seasonal cycle of a middle-latitude station with maxima in spring and summer caused mainly by stratosphere-to-troposphere exchange and downward transfer [2]. Due to photochemical reactions, the ozone (O_3) concentration in surface atmosphere also reaches maximum levels during summer. The daily O_3 variation, measured on a half-hour mean basis, however, shows maxima at noon and minima at night with values near zero. Therefore the question of how much of the surface air O_3 can be at-

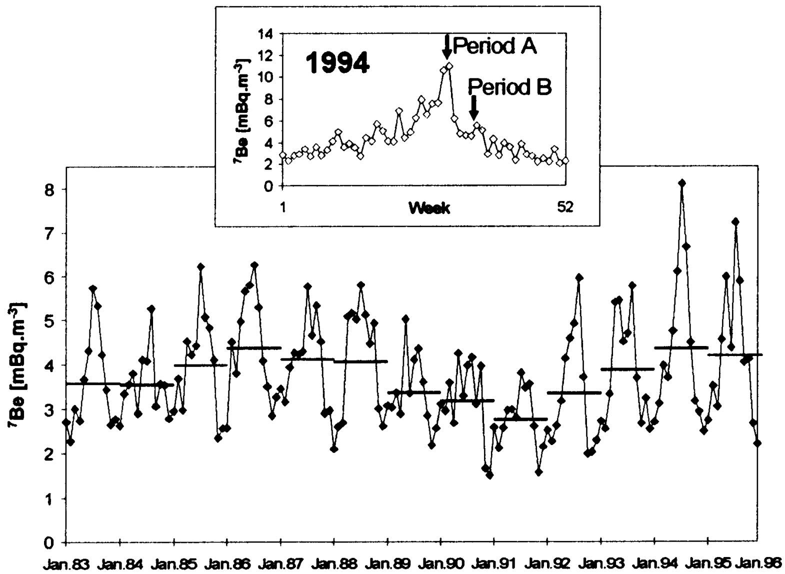

Fig. 1. ^{7}Be concentrations in ground air at Vienna (Hohe Warte) from 1983 to 1995. Monthly (◆) and annual mean values (——) calculated from weekly measurements. A and B mark two 14-day periods in summer 1994, during which more detailed investigations were performed together with simultaneous O_3 measurements

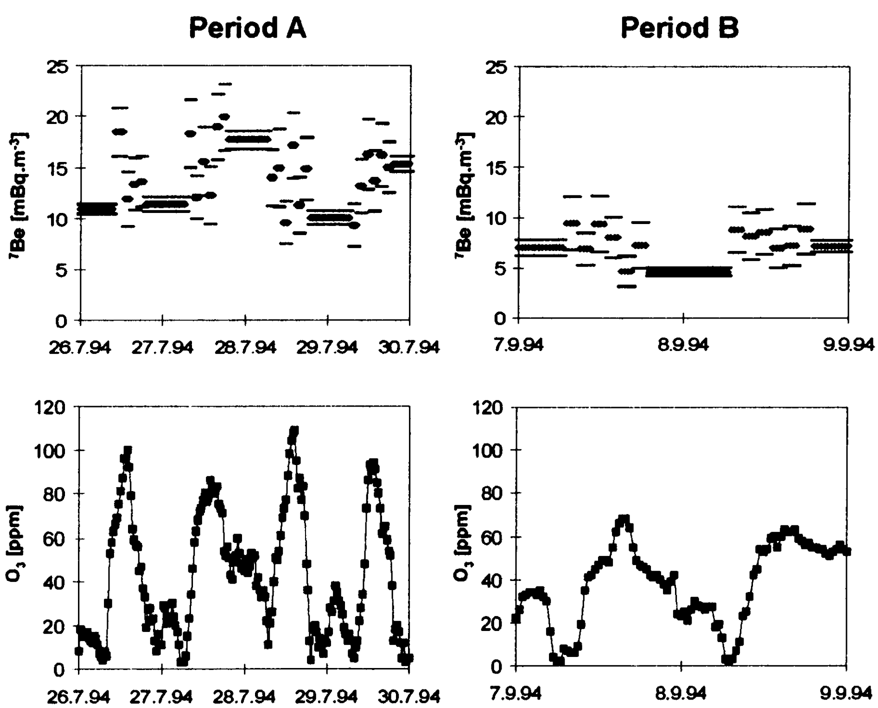

Fig. 2. Detailed ^{7}Be and O_3 concentrations in ground air a) 26–30 July (from period A) and b) on 7 and 8 Sept. (from period B)

tributed to stratospheric or higher tropospheric origin must be investigated in more detail. Comparing average ^{7}Be and O_3 concentrations over 24 h, as is usually done, is insufficient for drawing significant conclusions. In this paper a more detailed comparison is presented for the first time, along with correlation analyses based on our data from 2-h aerosol samplings of ^{7}Be, simultaneously measuring O_3 levels.

The surface air concentration of ^{7}Be has been measured routinely in Vienna since 1983 by collecting weekly aerosol samples. These results are plotted in Fig. 1, showing monthly and annual mean values within ranges of 1.5–8.2 and 2.8–4.4 mBq m^{-3}, respectively. Our sampling station in Vienna (Hohe Warte: 48° 15′ N and 16° 21.5′ E; 202 m a.s.l.) reports the typical maxima in spring and summer caused by enhanced vertical exchange within the troposphere. Other factors, such as horizontal transfer and especially wet scavenging, are not dominant in Austria during summer, although precipitation events clearly modify the ^{7}Be concentration pattern. A slight steady decrease of the annual mean from 4.4 to 2.8 mBq m^{-3} between 1986 and 1991 corresponds to the observed global trend reported by Larson [3]. This decreasing period, however, seems to us rather part of a longer cycle, because of the subsequent increase again to 4.4 mBq m^{-3} observed from then until 1995. Lal and Peters [4] assumed that the ^{7}Be source term, i.e., spallation processes due to bombardment of the nitrogen or oxygen atoms with cosmic ray particles in the stratosphere and the higher troposphere, depends on the 11-year solar cycle. They described a peak ^{7}Be concentration in 1954 due to a minimum of solar activity and a minimum ^{7}Be production in 1958 in accordance with the highest occurrence of sun spots. Hötzl et al. [5] more recently showed that from 1971 to 1989 the annual ^{7}Be concentrations measured in surface air and in precipitation in Germany were correlated with the solar cycle. They also found a ^{7}Be peak in 1986 together with a low number of sun spots and a peak of neutron count rates. Thus the ^{7}Be maximum in 1986 and the following minimum in 1991, as can be seen in Fig. 1, correspond to the third solar cycle since 1958.

In 1994 during two periods, namely 25 July–5 Aug. (A) and 29 Aug.–9 Sept. (B; see Fig. 1) we started additional aerosol sampling at 7:00 a.m., collecting at 2-h periods until 7:00 p.m. with a further 12-h overnight sampling, with O_3 levels being

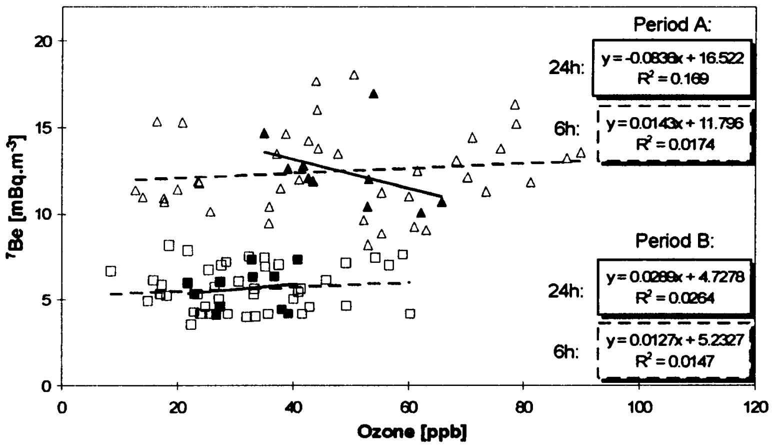

Fig. 3. Linear regression analyses of 24- and 6-h means of ^{7}Be and O_3 concentrations in ground air for two periods in summer 1994

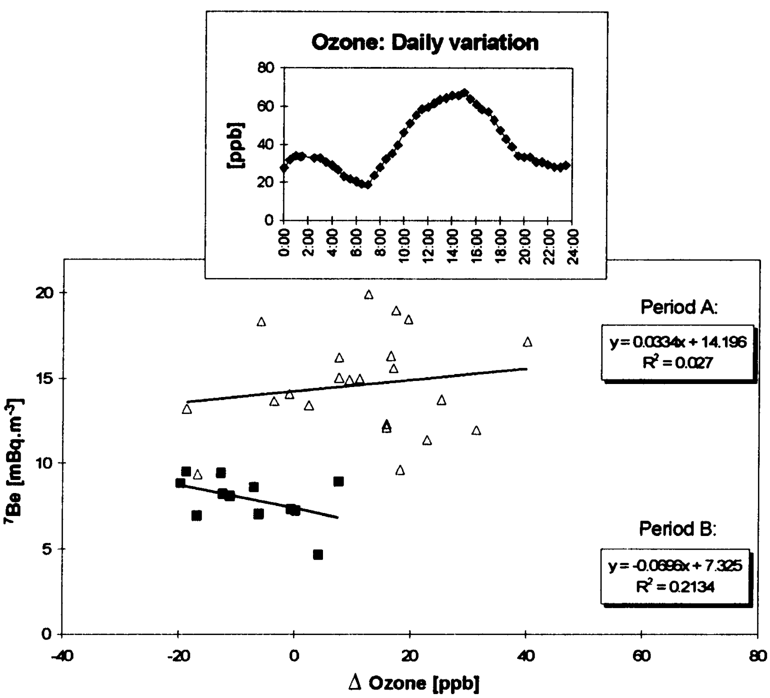

Fig. 4. Correlation analyses of the 2-h means of the O_3 deviations from the daily average values and the 2-h mean values of the ^{7}Be concentrations

measured simultaneously. The aerosol samples were collected 1.2 m above ground level with a high volume air sampler (flow rate: 80–90 $m^3\ h^{-1}$) using glass fibre filters. ^{7}Be determinations were carried out by γ-spectrometry with a REGe detector by evaluation of the 477.56 keV peak, with a counting time at least 600 min. Data presented in Fig. 2 are given with statistical uncertainties of ± 1.65 σ (standard deviation). O_3 data were obtained by automatic registration of 30-min means with an UV absorption spectrometer (Horiba,Type APOA-350 E).

As can be seen from Fig. 2, during both periods significantly enhanced ^{7}Be concentrations occurred together with increased O_3 levels. In a few cases an increment of approximately 5 mBq m^{-3} ^{7}Be over a 2-h period was correlated with about 10 ppb_v more O_3. This finding would agree with a nearly constant ratio of ^{7}Be/O_3 = 0.4 mBq m^{-3} / ppb_v in the stratosphere, as derived from aircraft measurements by Dutkievicz and Husain [6]. Such events, however, were rather short episodes, lasting only for about 1–2 h. On the other hand, inspection of our results also shows that despite ^{7}Be concentrations of 5–7 or even 10–12 mBq m^{-3}, the O_3 concentration decreased to just a few ppb_v. This suggests that additional O_3 contributions from stratospheric or higher tropospheric levels can be destroyed relatively quickly at ground level. Generally ^{7}Be and O_3 concentrations were much higher during period A, when a stable high-pressure system yielded hot, sunny days. This period ended with thunder storms accompanied by heavy rainfall, the mean temperature changing from about 26°C (maxima 34°C) to 20°C (maxima under 28°C) in the following B period.

Our first correlation analyses of these two fortnight periods are presented in Fig. 3. These results show only poor correlations, due to the time intervals considered. For 24-h mean values during period A a negative (!) correlation with a coefficient of r = 0.41 was obtained, which changed to a slightly positive one with r = 0.13 when using a 6-h mean value. For period B correlation coefficients of r = 0.16 and 0.12 were found, respectively. To eliminate the influence of locally produced O_3 we calculated the average daily variation in the O_3 concentration over both periods. This mean daily pattern (Fig. 4) agrees with the typical summer mean for our sampling station in Vienna as measured previously [7]. In a second step we calculated the differences between these average O_3 values and the 2-h means. We then correlated these deviations with the measured 2-h averages of the ^{7}Be concentration. This produced a slightly positive correlation for period A (r = 0.16) and for period B a negative one (r = 0.45). Due to the meteorological situation vertical exchange can be expected most probably during the hot days from 26–30 July and in the morning hours on 7 and 8 Sept. Viewed statistically, however, such events seem to be masked nearly completely by the varying local O_3 production. These results lead us to the conclusion that, at least during the period investigated, stratospheric or higher tropospheric contributions could hardly play an important role with regard to the high summer ozone levels found in the context of an urban area.

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Hearing in Geometrid Moths

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Ears sensitive to ultrasound have evolved several times among the families of nocturnal Lepidoptera, including at least once in the Geometridae [1, 2]. The ears of moths appear to have evolved with one main purpose, namely the detection of the calls of echolocating bats [3]. Only a few species use their hearing for sexual communication, presumably as a secondary adaptation [4]. Hearing organs occur throughout the family of Geometridae (c. 20 000 species) except in a few wingless females where they are lost secondarily. The tympana at the base of the abdomen are best seen when the abdomen is removed and viewed end-on. On the inside the two hearing organs are served by a common tracheal air sac. A sclerotized bridge, the *ansa*, which is unique for Geometridae, stretches across the tympanic membrane [1, 5, 6]. The scoloparium is suspended between the ansa and the tympanic membrane and contains four sensory cells, A_{1-4}. Their dendrites attach to the tympanum and fold back on themselves. Since the scolopales are therefore directed away from the tympanum, the scoloparium is said to be inverse [5, 6]. The unique morphology of the ear supports the contention based on phylogeny that the ears in geometrids evolved independently [1, 5]. Hence geometrid ears are neither homologous to the abdominal ears of Pyralidae nor to the much more thoroughly studied thoracal ears of Noctuoidea with their two sensory cells. Only little is known about hearing in different geometrid species [7, 8]. However, it seems likely that it is the predation pressure from bats which has prompted the evolution of ears independently both in the Noctuoidea and in the Geometridae. There are no published reports of sound production in geometrids. In addition, batlike ultrasound pulses elicit clear evasive maneuvers in geometrids ([9], own observations). The geometrids have relatively large wings and fly more slowly; thus they are presumably subject to at least as strong a selection pressure from bats as are noctuoids. Therefore we attempted to determine the auditory characteristics of some geometrid moths and to compare their hearing capability with noctuid moths. Thus we hope not only to increase the knowledge of geometrid audition but also to provide further insight into the general principles of evolutionary interaction between moths and bats.

There are six subfamilies of Geometridae with around 300 species in Denmark. We determined the audiograms of seven species of two subfamilies, Geometrinae and Ennominae. All the moths we chose for this study are relatively large, with wing spans between c. 35 and 47 mm [10]. Thus they are among the acoustically most conspicuous geometrids and therefore presumably subject to maximum predation pressure by bats. We caught the moths in light traps in the vicinity

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