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Arsenic in the Dunlin (Calidris alpina) from the Dutch Waddenzee

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The Waddenzee is a large estuarine area in The Netherlands which has an important significance in the life cycle of waders. However, this area is severely polluted by the rivers Rhine and Scheldt. These rivers flow into the North Sea about 100-150 kilometers to the south and part of their load of pollutants, including many toxic elements, is transported by the prevailing currents into the Waddenzee.
In an investigation into heavy metal contamination of waders in the Waddenzee, it was found that Arsenic concentrations were higher in adult feathers formed in this area than in juvenile feathers formed on the remote breeding grounds.
In a few organs, which were analysed for As, also relatively high concentrations were detected (Goede in press). Therefore As accumulation in this group of birds, with the Dunlin as representative, has been further investigated. Thereby special attention has been paid to the significance of feather As-concentrations for environmental research.

MATERIALS AND METHODS

The Dunlin breeding grounds are (sub-)arctic. After the breeding season many adults and juveniles migrate via Scandinavia to the Waddenzee to moult. Ten birds, 5 juveniles and 5 adults, have been sampled in the middle of August 1982 at Ottenby, Sweden while migrating; at the same time, i.e. shortly after their arrival, a similar sample was collected in the Western part of the Waddenzee. The aim was to obtain additional samples at one month intervals until December, from both the Eastern and the Western part of the Waddenzee. This was not completely successful, and the only additional samples obtained were 2 adults and 2 juveniles collected in September and 5 adults and 5 juveniles collected in November 1983 in the Eastern part of the Waddenzee. Adults undergo a complete moult in this time of year; juveniles retain the flight feathers formed on the breeding grounds and moult the small feathers only. In the first three months of the collection period the adults were selected on basis of moults stage and weight. August birds had to be at the beginning of their

primary moult; September birds at the end of this moult and in October only birds with completed primary moult and weight above 57 g were collected. These stages represent three distinct periods in the weight cycle during adult post nuptial moult (Goede and Nieboer 1983) and thus birds were collected in the same physiological condition each sampling period.
Kidney, uropygial gland ('preengland') and vanes of the 8th primaries were analysed for As by instrumental neutron activation analysis, using the system for routine analysis developed at the IRI (De Bruin and Korthoven 1972, De Bruin et al. 1983). The sample preparation has been described elsewhere (Goede in press). Repeated analysis of reference material gives for As a precision and accuracy of the method better than 10%.
Tissue concentrations will be given in dry weight and means with standard deviations.

RESULTS AND DISCUSSION

No differences were observed between adults and juveniles with respect to As-concentration in kidney and preengland. Therefore, the data from adults and juveniles were combined.
In the birds collected while migrating in Sweden, Arsenic kidney concentrations were all below the detection limit (0.35 $mg.kg^{-1}$). However, for seven out of eight birds collected in the Western part of the Waddenzee shortly after arrival, the kidney concentrations were already elevated. In October a mean value of nearly 6.6 $mg.kg^{-1}$ was reached. Kidney concentrations in birds from the Eastern part also increased, but remained on a lower mean level than those from the Western part (Fig. 1a).
For Swedish birds, the preengland concentrations were all below the detection limit (0.20 $mg.kg^{-1}$). In the Waddenzee these concentrations increased in a similar way as described for the kidneys, except that the preengland concentrations were at the average a factor three lower (Fig. 1b). A significant ($p < 0.001$) positive correlation was found between kidney and preengland concentrations (Fig. 2).
For the juveniles, with the exception of one sample (2.5 $mg.kg^{-1}$, August, Western Waddenzee), all primary vane concentrations were below 1.0 $mg.kg^{-1}$. For the adults, all vane concentrations except three were above 1.0 $mg.kg^{-1}$. Concentrations in the one year old vanes of the August birds did not differ from those in the newly grown vanes, and in the different sampling periods concentrations did not differ either. No difference was found between birds from the Eastern and Western part of the Waddenzee. Adult As vane concentrations showed a skewed distribution pattern (Fig. 3).
The As-concentrations in the preengland show an increase parallel to that in the kidneys. This might suggest an excretion of As via the preengland, which would be in agreement with the findings of Overby and Frederickson (1965) for leghorns. In their experiments, 48 h after both oral and intraperitonial administration of

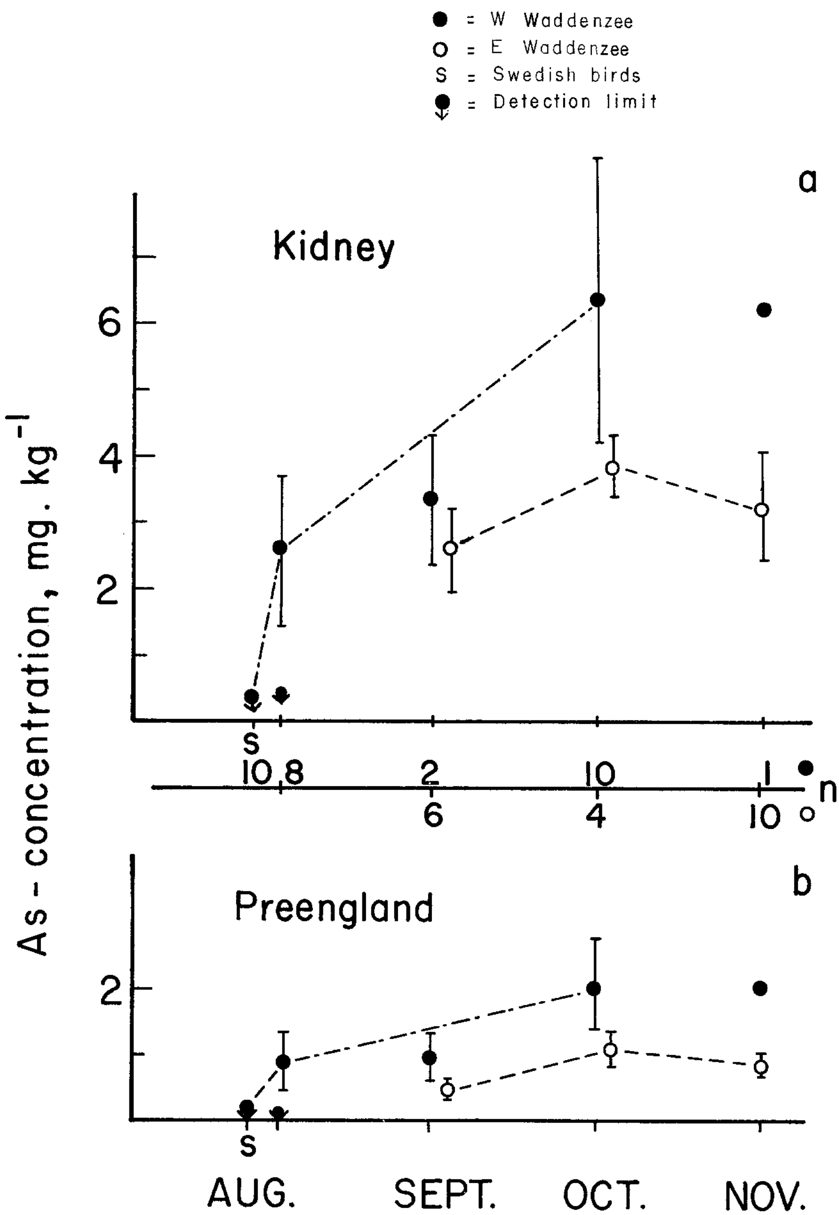

Figure 1 Arsenic concentrations in kidney (a) and preengland (b) of the Dunlin as a function of time

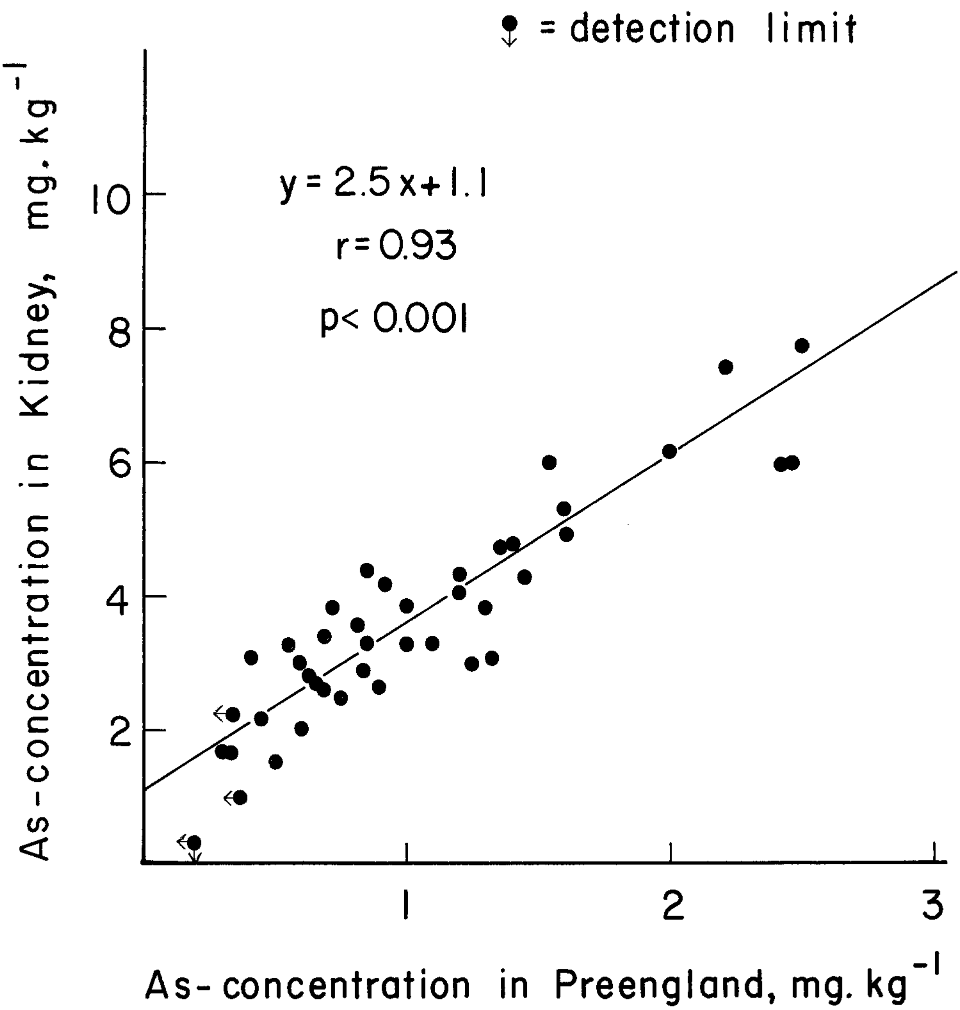

Figure 2 Relation between the As-concentrations in preengland and kidney

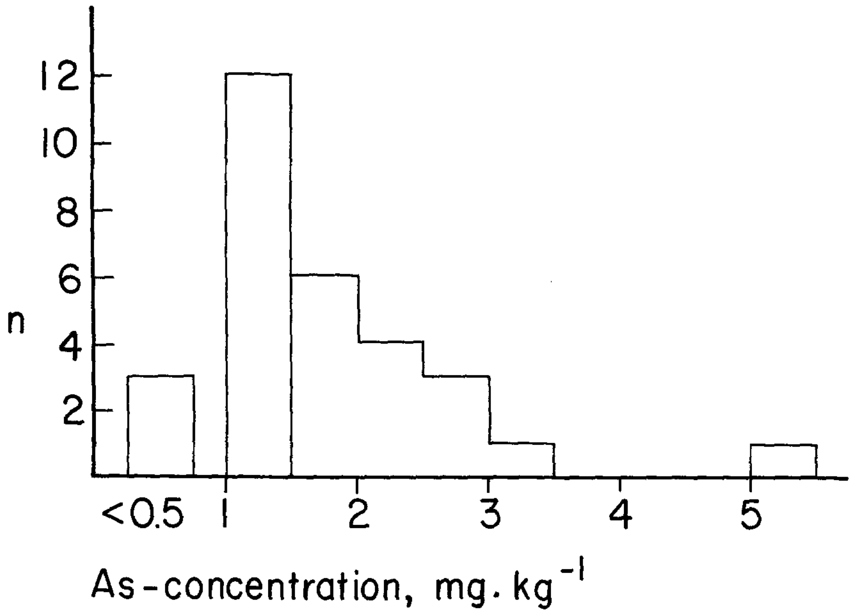

Figure 3 Frequency distribution of As-concentrations in primary vanes of adult Dunlins

radio-activily labelled arsanilic acid and arsenate, the feathers were the tissue showing the highest activity. This obviously indicates feather contamination by excretion products of the bird, as feather material is a dead tissue and internal deposition after feather formation can be excluded.
Juvenile Dunlins show an increase in kidney and preengland As-concentrations with time similar to that found for adults. No evidence was found for contamination of juvenile primary feathers formed while at the remote breeding grounds. Therefore it can be assumed that also for adult birds, no or only slight external contamination occurs during that period. This implies that the primary vanes reflect the deposition of As during feather formation. Differences in kidney concentrations for adult Dunlins from the East and from the West Waddenzee do not show up in the vane concentrations. This means that the feathers do not respond proportionally to the exposure of the bird to As. Therefore, the feather vane can not be used as a monitor but only as an indicator for exposure to As.
The adult vane concentrations show a skewed distribution, similar to that observed for hair. This indicates that As is a non-essential trace element which concentration is not internally controlled (Liebscher and Smith 1968). Hence, like in mammals, toxicological effects of high concentrations might be possible (Buck 1978). White et al. (1980) reported for waders wintering in an industrialized bay mean liver levels of 0.05-0.23 ppm on wet weight basis with for Dunlins a mean of 0.07 ppm and a range of 0.05-0.35.

Goede (in press) found for waders a positive linear correlation between liver and kidney concentrations, the liver concentrations being twice the kidney concentrations. Taking this into account, relatively high As liver concentrations can be expected for Dunlins from the Dutch Waddenzee. Possibly adverse effects on the birds have still to be investigated.

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