APPENDIX

The concept of a quantile is closely connected with the familiar concept of percentile. We define the .65 quantile of a set of data to be a number on the scale of the data that divides it into a fraction of .65 of the observation below and a fraction of .35 above. The median of the data is therefore .5 quantile. An effective method for making comparisons of the distributions of two data sets is to plot the quantiles of each distribution against the other. In this paper I have been interested in comparing the frequency distribution of Knot wing lengths against the normal distribution. Therefore I have plotted a theoretical quantile-quantile plot, with the empirical quantiles of wing length plotted against the corresponding quantiles of a normal distribution (sometime called a normal probability plot). When the quantiles in the data closely match the theoretical quantiles, the points on a quantile-quantile plot will fall near the line y = x.

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ELEMENT COMPOSITION OF FEATHERS CHARACTERIZE KNOT *CALIDRIS CANUTUS:* A TESTCASE

by A. A. Goede

INTRODUCTION

Discriminating populations within a species is usually made on the basis of a combination of biometric data, weight, moult and ringing recoveries. However, the feathers may carry a "fingerprint" of the areas the birds have lived in, either by the incorporation of elements in the keratine during feather growth, or by external contamination of the feathers. Determining the chemical composition of the feathers might prove to be a useful tool in discriminating between populations with different backgrounds (Hanson & Jones 1976).

Recently, knowledge of the migration of the Knot *Calidris canutus* in western Europe and Africa has increased dramatically. Two subspecies of the Knot occurring in western Europe are recognized: *C. c. canutus* breeding in Siberia, migrating through western Europe and moulting and wintering in Africa; and *C.c. islandica*, breeding in Greenland and NE Canada, and moulting and wintering in western Europe (Roselaar 1983). On spring migration the two subspecies seem to remain temporally segregated, though some use the same staging areas in the German Wadden Sea (Dick *et al.* 1987). They mingle extensively only in autumn (Boere *et al.* in press). Important spring staging areas in northern Norway were discovered recently and Davidson *et al.* (1986) established that the Knots occurring there, in contrast to previous assumptions, belong to the subspecies *islandica*.

This paper attempts to distinguish two subspecies on the basis of element concentration in the feathers.

MATERIALS AND METHODS

Primary no. 8 of adult Knots were collected on the island of Schiermonnikoog in the Dutch Waddensea (30 October, 1 November 1979); Balsfjord, Norway (12 May 1985); Westerhever (19 March 1987) and Norderheverkoog (19 May 1987) both in the German Wadden Sea; and from one bird at Sidi Moussa, Morocco (23 April 1982). According to the previously cited literature, the Dutch, Norwegian and March German birds should belong to the Nearctic breeding population and the Moroccan and May German birds to the Siberian population. In addition, three adults from the collection of the Zoological Museum in Amsterdam, found dead in the Dutch Waddensea in May 1931, 1964 and 1967 were sampled. Two had bill lengths of 40.4 mm and 38.2 mm and were found 12 and 25 May respectively. They are considered to be Siberian. The third, with a bill of 28.9 mm and collected on 5 May, is considered to be Nearctic.

The vane of the feather was analysed for selenium (Se) (only the spring samples), mercury (Hg), and arsenic (As) by means of instrumental neutron activation analysis, a method described elsewhere (Goede and de Bruin 1984, de Bruin *et al.* 1982). Feather vanes from the museum skins were analysed only for selenium. Available data on primary 8 vane concentrations of these elements in other wader species (Dunlin *Calidris alpina alpina*, Bar-tailed Godwit *Limosa lapponica*, Redshank *Tringa totanus robusta*, Oystercatcher *Haematopus ostralegus*) are used for comparison.

RESULTS

Mercury concentrations in the feather vanes of the Dutch, Norwegian and March German birds are similar, but the Moroccan and May German values are much lower than these values (Figure 1).

Also the spring selenium concentrations in the feathers of the Norwegian, March German birds and the Dutch Nearctic May birds are similar, and again the concentrations in the Siberian Knots are much lower (Figure 1).

Within the Nearctic Knots there appears to be a difference in arsenic status (Figure 2a-c). The Norwegian Knots have significantly higher concentrations in the primary 8 vane compared with the Dutch and German Waddensea birds (Student t-test $p<0.0005$) (in testing, the extreme value of 21.0 mg/kg in the Dutch sample has been disregarded).

Data from various different wader species (adults moulting in western Europe) sampled over several years and on different locations all show a similar distribution of arsenic concentrations to the data of the Waddensea Knots (Figure 2d). Also first calendar birds sampled in the Dutch Waddensea have low arsenic concentrations: 95% have < 1.0 mg/kg and 5% have 1.0-2.0 mg/kg in the primary 8 vane (Redshank n=8, Knot n=26, Dunlin n=31, Bar-tailed Godwit n=10, total n=75).

DISCUSSION

The mercury concentration in the feather is

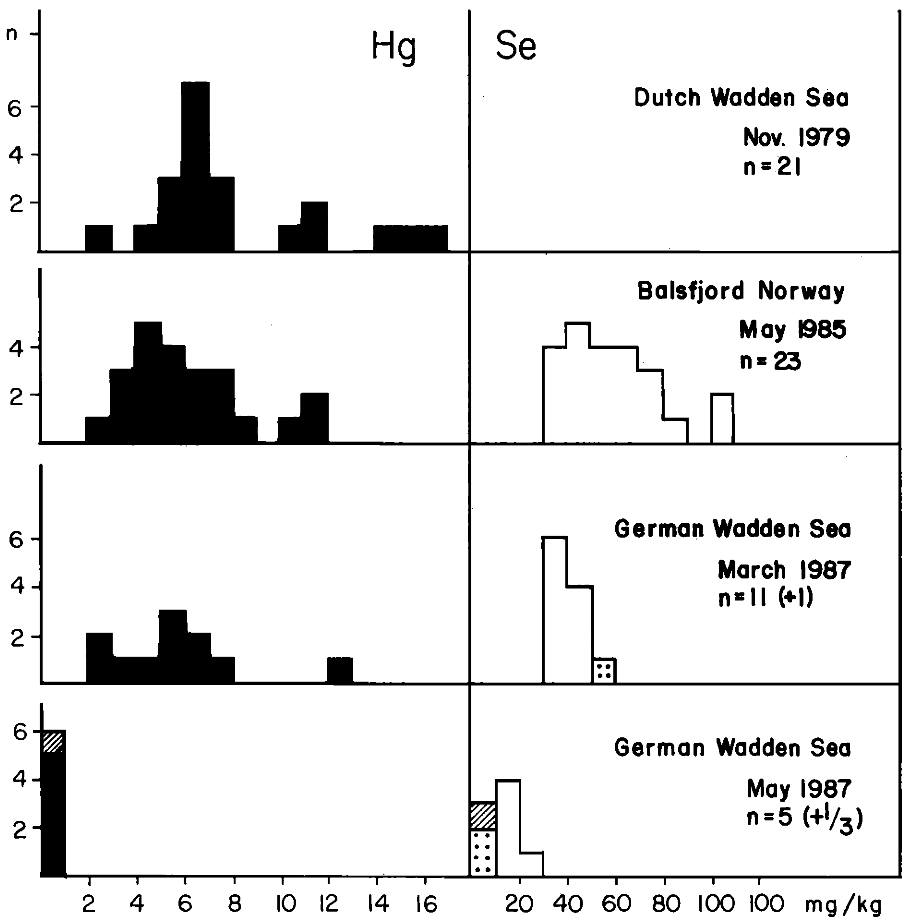

Figure 1. Frequency distributions of mercury (Hg) and selenium (Se) concentrations in primary no. 8 vanes of adult Knots. The stipples samples are Dutch museum specimens; the diagonal shading is a bird from Morocco.

very stable and no changes occur during the lifetime of the feather (Applequist *et al.* 1984). Mercury is an element that becomes incorporated in the keratine during the formation of the feather. Previously accumulated mercury in the body is mobilized and deposited as is ingested mercury at times of moult. Primary no 8 is one of the later grown feathers during the primary moult. When, as in this case, exposure to mercury is low between pre- and postnuptial moult, it is believed that most if not all mercury found in the keratine is from the diet at time of moult (Goede *et al.* in prep.). Since mercury is a pollutant (which might increase or decrease with time) in some areas, comparisons between different samples can only be performed if the samples are collected within a relatively short period of years.

During their stay in west European estuaries, the feathers of marine waders become externally contamined with selenium (Goede and de Bruin 1984, 1985, Goede *et al.* in prep.). Hence, only samples collected in the same period of the year can be compared. A Knot collected in 1930 had a selenium feather concentration similar to those of its conspecifics half a century later at the same location and time of year, indicating that samples collected over a longer time span may be compared.

Despite the rather small samples, the data presented here regarding mercury and selenium feather concentrations, indicate that the Dutch November, Norwegian and March German Knots belong to one population, i.e. a population moulting (Hg) and wintering (Se) in an area with certain mercury and selenium characteristics. The Moroccan Knot and May German Knots seem to belong to another population, i.e. moulting and wintering in an area with completely different mercury and selenium characteristics. This corroborates the conclusion that the Norwegian birds indeed belong to the Nearctic and the May German birds to the Siberian breeding populations.

In addition to these results, a surprising difference in arsenic concentration occurs in Nearctic Knots in different places. In a previous investigation data were inconclusive with regard to whether the feathers become externally contaminated with arsenic (Goede and de Bruin 1984). Therefore the arsenic found in the Norwegian Knots may originate from either (a) the wintering area, (b) the moulting area, or (c) the breeding area. These possibilities are examined below.

a) The wintering area. The elevated feather concentrations of the Norwegian Knots may result from external contamination during the stay in their wintering area. According to ringing recoveries this is mainly Great Britain (Uttley *et al.* 1987). However, the ringing

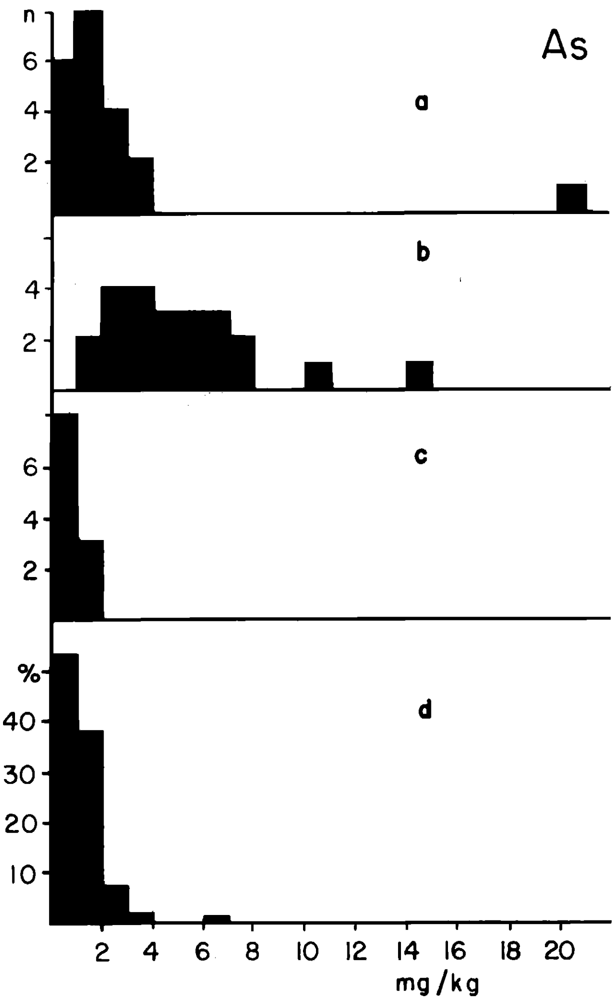

Figure 2. Frequency distributions of arsenic in the primary moult vanes of adult waders. Data are for Knots. a) Dutch Wadden Sea, 1979, n=21; b) Balsfjord, 1985, n=23; and c) March, German Wadden Sea, 1987, n=11; and d) other species: Dunlin, Dutch wadden Sea, n=52; Bar-tailed Godwit, n=37; Icelandic Redshank, n=22; Oystercatcher, n=92; Oystercatcher, Norway, n=25; and Dunlin, Norway and Sweden, n=9; sampled between 1979-1987 (total n=238).

recovery data of early spring German Knots (Prokosch, *in litt.*) show that these birds use the same wintering area but have low arsenic concentrations. Only if it is assumed that because of their early collection date of 19 March, the German Knots belong to the Waddensea wintering population, is this possibility valid. Feathers of Dunlin (*C.a. alpina*, also mainly wintering in Great Britain) sampled in spring 1985-86 (n=28) in the Waddensea showed no contamination (Goede *et al.* in prep.). Two out of 25 breeding Oystercatchers caught on a Norwegian island (1987) had been banded in the Wash; they had also low concentrations in their feather vanes (these Dunlin and Oystercatcher data are included in Figure 2d). Hence these last two observations do not support the possibility of winter contamination.

<u>b) The moulting area</u>. Ingested arsenic at time of moult may have been deposited in the growing feathers. Since a number of recoveries among the Balsfjord Knots originated from the Waddensea in the post nuptial moult period (Uttley *et al.* 1987), a substantial part of the Balsfjord population should then have arsenic concentrations in the range 0-2 mg/kg. The majority of the Waddensea concentrations fall within this range, but only 9% of the Balsfjord birds satisfy this condition.

<u>c) The breeding area</u>. Ingested arsenic on the breeding grounds may have been accumulated in body tissues and mobilized at time of moult to be deposited in the growing feathers. If so, a substantial part of the Waddensea moulting Knots should have arsenic concentrations higher than 2 mg/kg, since the recoveries show that part of the Knots from the Balsfjord spring population moult in the Waddensea in autumn. Indeed one third of the Dutch Knots have concentrations that high.

Differences in arsenic exposure in arctic areas do occur. Maps in the Geochemical Atlas of Northern Fennoscandia, Kautsky (1986) show the distribution of arsenic in soil collected 50-60 cm deep and in bryophytes (stream mosses) collected from stream beds. These make clear that layers deposited by glaciers do contain different amounts of arsenic and the similarity of the distribution patterns of arsenic in soil and stream moss shows that this arsenic is bioavailable, and that bioaccumulation occurs: (the maximum concentration in soil is *c.* 20 mg/kg and in stream moss is *c.* 200 mg/kg dry weight).

No firm conclusions can be drawn yet. It would be most interesting if the breeding area is responsible for the differences in arsenic status. It would imply that the majority of the Knots moulting in the Waddensea in autumn do not migrate via northern Norway in spring and use distinctly different breeding areas to the Balsfjord birds. Such a possibility awaits further investigation of the migrations of Knots.

CONCLUSIONS

Having shown from mercury and selenium analyses that the Siberian and Nearctic populations of Knots migrating through western Europe in spring can be identified, this test case has demonstrated that determining the chemical composition of the feather can be a useful tool in discriminating populations. Though it cannot yet be predicted which elements will be of most use as a "tracer" for each species in each area. The advantage of the use of neutron activation for analysis of heavy metals, is that a single analysis provides information on the concentrations (or detection limits) of a large number of elements. (The detection limits depend on sample weight and composition of the sample.) The costs are comparable to those of alternative techniques: at our Institute total costs of analysing one sample for elements with isotypes with a short half-life (seconds-minutes) is currently approximately Dfl 25 and with a longer half-life (hours-months) Dfl 125. When all labour is done by the investigator the costs are respectively Dfl 15 and 75 per sample (£1 = *c.* 3.5 Dfl).

A REQUEST FOR SAMPLES

In the framework of my investigations into the significance of selenium to marine waders, I would like to look further into the difference in selenium exposure between birds of one species. Therefore I would be most grateful to receive <u>spring/summer</u> samples of Nearctic and Siberian <u>adult</u> Knot <u>primaries</u>. The primary should be no. 8, of both wings. The best collection method is to pull them out. A secondary result of the analyses would be greater insight into the whereabouts of the Nearctic Knot populations. In particular a comparison between Icelandic and Norwegian spring samples would be of interest in this respect.

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NEW WORLD SECTION

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SHEPODY BAY, BAY OF FUNDY: THE FIRST HEMISPHERIC SHOREBIRD RESERVE FOR CANADA

by Peter W. Hicklin

In the latest Wader Study Group Bulletin supplement (No. 49, IWRB Special Publication No. 7) Myers *et al.* (1987a) described the "Western Hemisphere Shorebird Reserve Network" and its role as a shorebird conservation strategy (see also Myers *et al.* 1987b). A few months following its publication a significant event took place in the development of this conservation initiative as a new member site formally claimed membership in the network.

On 8 August 1987, Mrs. Pauline Browes, Parliamentary Assistant to Canada's Environment Minister Tom MacMillan, Mr. Malcolm MacLeod, Provincial Minister of Natural Resources and Energy (New Brunswick) and Mr. Stanley Malone, Head of the Suriname Forest Service, unveiled a bronze plaque at Mary's Point in Shepody Bay which read in part:

> SHEPODY BAY: INTERNATIONAL SHOREBIRD RESERVE
>
> Shepody Bay is Canada's first Western Hemispheric Shorebird Reserve recognizing its importance to over one million shorebirds which annually stop en route from Canada's Arctic to South America. It is also recognized as a Wetland of International Importance under the Ramsar Convention (1971).

This symbolic event by public officials was witnessed by over 200 invited guests, members of the media, and about 50 000 Semipalmated Sandpipers *Calidris pusilla* roosting within