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# Strøby Egede, Vedbæk-Bøgebakken and Relationships among Scandinavian Mesolithic Skeletal Material

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*This paper derives from new work on Mesolithic human skeletal material from Strøby Egede, a near coastal site in eastern Sjælland, with two foci. The first confirms sex identifications from original work carried out in 1986. The second, and central focus, re-examines comments by one of us (CM) based on work in 1992, and a new statistical analysis including data from the two Strøby Egede adults. In 1998 it was suggested that the Strøby Egede sample more closely resembled Skateholm, on the coast of Skåne in southern Sweden, than Vedbæk-Bøgebakken on Sjælland, fitting lithic patterns noted earlier by Vang Petersen. We revisit the 1998 suggestion below, comparing data from Strøby Egede to those available from southern Scandinavia and Germany, and suggest that the 1998 comment was, in all probability, incorrect. The analysis below suggests overall morphological similarity between individuals in eastern Sjælland and Skåne, while noting the existence of apparent outliers.*

**Keywords:** Scandinavia, Mesolithic, human skeletal material, Strøby Egede, Vedbæk-Bøgebakken, craniometric analysis, principal component analysis, cluster analysis

## THE CONTEXT AND THE PROBLEM

This paper revisits a suggestion made in Meiklejohn *et al.* (1998), a paper derived from the 1992 conference at Reciezki Mlyn in north-western Poland focused on the circum-Baltic Mesolithic–Neolithic transition (Zvelebil *et al.* 1998). It derives from work by Gron *et al.* (2022) on the skeletal material from Strøby Egede, a Middle Ertebølle site in eastern Sjælland,[1] discovered in 1986 and partially published between 1987 and 1991 (see below). However, several factors prevented a full description of the skeletal material, as summarised by Gron *et al.* (2022). The paper below is divided as follows:

- A brief overview of the 1986 discovery, its context, and initial findings;
- A revisiting of the context for the 1998 suggestion about relationships of the Strøby Egede series and its statistical basis; and
- A new statistical analysis examining the relationship of the Strøby Egede adults to Mesolithic skeletal series in Scandinavia and Germany.

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## THE 1986 STRØBY EGEDE DISCOVERY AND THE INITIAL PUBLICATIONS

In the summer of 1986, a multiple burial with eight individuals was discovered during extension of a carp pond in a backyard on the western edge of the town of Strøby Egede, *c.* 5 km south-east of the centre of the town of Køge and just outside the boundary of Køge Municipality, south of København (Copenhagen). The site has also been identified as Engvangsvej 52, the address of the discovery. The events that followed were described in articles published between 1987 and 1991, as reviewed by Gron *et al.* (2022). Briefly, the burial was recovered from a habitation site lying *c.* 0.5 km east of the valley of Tryggevælde Å, a small stream flowing into Køge Bugt, which currently lies *c.* 2 km away. We stress the association of the burial with a Mesolithic habitation site, still unexcavated due to its setting in a housing development on the north-west side of the town. Remains recovered from the burial included diagnostic Ertebølle lithics, identified during early work and dated to *c.* 6650 BP. Bone preservation has prevented direct radiocarbon dating of any of the recovered individuals (Brinch Petersen 1990a; 1990b). The context is similar to other riverine estuaries or fjords with sites on the eastern Sjælland coast, though the southernmost of those currently known. Other primary site groups are those from the Vedbæk and Nivå fjords, both north of København.

The Strøby Egede burial is distinct in having the largest number of individuals, eight, from a single feature in Mesolithic Scandinavia. Initial publications were based on what was visible during excavation (Brinch Petersen 1987; 1988; 1990a; 1990b). Given the location, no *in situ* study was possible, with the feature transported, *en bloc*, to the Preservation Laboratory, Nationalmuseet, København, for further limited study. Finally, it was moved, again *en bloc*, to Køge Museum, where it remains on display. The analysis below centres on work in 1992 by one of us (CM) at Køge Museum, within the confines of the reconstructed burial display. Three individuals could be measured, the two adults, individuals A and D, and the single adolescent, C. Further individuals were all infants and children. The study below uses data from the adults, a female and a male. For reasons, including the impossibility of a complete skeletal analysis while on open display, the only full description of the series is that of Brinch Petersen (1988). The Strøby Egede data used below has been published as a Supplementary Information document to Gron *et al.* (2022).

## CONTEXT FOR THE 1998 SUGGESTION ABOUT THE RELATIONSHIP OF THE STRØBY EGEDE INDIVIDUALS

As noted above, this paper is based on comments in Meiklejohn *et al.* (1998), written in 1993 and 1994. It combined ideas delivered separately by CM and Erik Brinch Petersen at the 1992 Polish conference, with the specific comments stemming from analysis of Danish Mesolithic cranial data collected by CM between 1986 and 1993, with further published data included, as discussed below. The 1993/1994 analyses, based on canonical analysis, were performed by Jeffrey M. Wyman, then research assistant to CM at the University of Winnipeg.

A query arising is why the question below is not answered by use of aDNA, or comparison of results obtained from craniometrics and aDNA, given how the latter has taken centre stage in bioarchaeology. We do not question application of aDNA but see two reasons for using craniometric data in this paper. The first relates to availability of aDNA data or, in this case, its absence associated with the individuals and sites discussed below, particularly those from Scandinavia and especially the three primary Ertebølle period sites discussed, Vedbæk-Bøgebakken (henceforth Bøgebakken), Skateholm, and Strøby Egede. As clearly stated by Allentoft *et al.* (2024, 329): 'insight into the fine-scale structure and mobility of Scandinavian Mesolithic populations is limited, including an *almost complete absence* of genetic data from southern Scandinavian populations associated with the consecutive Maglemose, Kongemose and Ertebølle cultures in Denmark' (emphasis ours). This clearly makes detailed comparison with the 1998 results, based entirely on craniometric data, difficult to impossible. Though five Bøgebakken individuals have associated mitochondrial aDNA results (*ibid.*, supplementary data), none are from individuals with suitable craniometric data. In addition, no aDNA results appear to have been published from either of the other core sites, Skateholm and Strøby Egede, or from any of the other Scandinavian or German sites discussed in 1998 or below.

The second reason for using craniometric data, beyond permitting direct comparison of the new and the 1998 analyses, is work showing that such data are applicable to the study of human group relationships. Though some have questioned such application, work over the past quarter century has supported use of craniometrics for study of population groups over time, such as Brace *et al.* (2001) with reference to New World groups. Much more recently, Rathmann *et al.* (2023) have shown that both craniometric and dental data follow the same pattern as does aDNA, involving 'neutral evolutionary processes' and acting as 'reliable proxies for inferring population structure and history'. Further to the point, craniometric data, along with dental non-metric data (not available here), provided the clearest information. Further to the above,



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available aDNA mitochondrial haplogroups from Scandinavian Mesolithic samples are highly homogeneous, as widely observed. As a result, there is no available aDNA evidence that allows for conclusions about intersite relationships, the core topic in our paper.

The 1998 commentary was framed within discussion of Late Mesolithic population density in Denmark and how it might be studied, influenced by the population replacement model of Ammerman and Cavalli-Sforza (1984). However, work in Denmark by this time suggested that, by the Kongemose (7400–8400 BP), the Sjælland population was already dense and stable rather than marginal. This was clearly incompatible with Ammerman and Cavalli-Sforza's assumption that, before the arrival of the Neolithic, Mesolithic groups were low density and semi-nomadic. Their model for the transition assumed densities of 0.02/km$^2$ for the Mesolithic and 1/km$^2$ for the Neolithic. In contrast, the model presented in 1998 suggested roughly identical Mesolithic and Neolithic densities, and a Mesolithic population with groups that might be statistically detectable by craniometric analysis, leading to the following suggestion (Meiklejohn *et al.* 1998, 209):

> 'Some support to a model of group separation and identity comes from analysis of … samples from the Sjælland and Skåne populations using a Canonical Analysis of cranial metrics. … Due to the fragmentary nature of the Skateholm sample … five vault measurements w(ere) used. A Portuguese sample (Muge) was added to test the degree of discrimination. All Scandinavian samples fell outside the Portuguese range … (S)amples from Skateholm and Bøgebakken were also fully separated, suggesting that they may well belong to different biological populations. However, the spread of the Bøgebakken series shows this sample to be more variable than any other reported for the Mesolithic of western Europe. The adult from the Gøngehusvej 7 inhumation and two of the adults from Strøby Egede were also added … both … separated from Bøgebakken and closer to Skateholm. The first of these findings is more difficult to interpret. It does, however, bolster the idea that the Vedbæk sample, overall, is highly variable. *Moreover, the separation of Strøby Egede from Bøgebakken is intriguing. It matches the regional clustering demonstrated by Vang Petersen (1984) … based on lithic typology and style* (emphasis added). We thus have evidence to suggest that biologically separated populations were already present in southern Scandinavia by the Late Kongemose or Early Ertebølle'.

The above quote had an attached comment that the analysis would be published elsewhere. Unfortunately, it was not. The suggestion of biologically identifiable groups has remained unchallenged. Given the recent paper by Gron *et al.* (2022) we decided to revisit the 1998 model, especially since Gron and colleagues discussed the type of society that might result in the Strøby Egede multiple grave. As noted above, the canonical analysis separated Scandinavian from Portuguese Mesolithic data collected by CM in the 1980s (Moita do Sebastião, Cabeço da Arruda), indicating regional morphological variability in the Mesolithic.[2] In addition, Bøgebakken in Sjælland and Skateholm in Skåne were 'fully separated'. It was further noted that the Bøgebakken sample was more variable than other Scandinavian sites and those from Portugal. The 1998 conclusion, that some Sjælland groups *might* be more closely related to southern Swedish groups than to Bøgebakken, matched Vang Petersen's (1984) patterning of lithic material though Vang Petersen did not posit relationships with Sweden but showed clear separation of lithically identified groups in Sjælland. What follows revisits the 1998 results, using different methods and a database assembled between 2008 and 2016.

Finally, we clarify that we do not have access to details of the 1998 analysis, beyond the statistical approach used, the sites mentioned in 1998, and use of Portuguese data as an outlier. We know that the primary restriction in 1998 involved the Skateholm dataset, a situation still present today. Limitations in the Skateholm dataset means that the variables we use in this paper are generally similar to those available in 1998, and probably identical. Though the Skateholm series is the largest from a Scandinavian Mesolithic site or site group (eg, the Vedbæk and Nivå fjords), preservation is poor. The current database has craniometric data from 34 Skateholm individuals, 18 from Skateholm I, 15 from Skateholm II, and one from Skateholm III, but the number of variables per individual is very limited, only averaging 7.26. Five variables were used in 1998. Our current database allows for full datasets, including Skateholm, with five, six, or nine variables, though none includes more than three Skateholm individuals, one male and two females. It is also highly probable that the 1998 dataset was from Skateholm I, the best-preserved of the Skateholm sites. We are therefore not fully sure which individuals were used in 1998. Finally, it is highly probable that the dataset was analysed as both sexes combined, an approach in use in the laboratory in the period when the analysis was performed, as in Meiklejohn *et al.* (1994). We should add that the five variable set used below in Analysis set A is the same as used in 1998 and was therefore used below rather than the six-variable possibility.

In conclusion to this section, we are aware that the small sample sizes available for the three primary sites, two in Sjælland and one in Skåne, limit the overall statistical validity of the conclusions we have made. We nevertheless support the conclusions made below within the context of the overall discussion.

## NEW STATISTICAL ANALYSIS

The rest of the paper focuses on two overlapping statistical analyses, one with five variables, as in 1998 (see above), the other with nine. These are sequential, with the second exploring questions raised by the first and covering a larger geographic area. The database from 2008 to 2016 was constructed by one of us (CM), assisted by Ron Pinhasi and Winfried Henke, and included all known published data on European Mesolithic and Upper Palaeolithic human crania, together with previously unpublished data collected by the three. Elements of it have been used elsewhere to suggest population discontinuity in Europe at the Late Glacial Maximum (Brewster *et al.* 2014a; 2014b) and in Mesolithic studies by the authors of this paper (Meiklejohn & Babb 2015; Meiklejohn *et al.* 2012; Mullan *et al.* 2017; Schulting *et al.* 2019). The two analyses centre on whether the Strøby Egede individuals might be more closely related to groups in southern Skåne than to those in northern Sjælland, including Bøgebakken, as suggested in 1998.

Further comment is needed on the Skateholm data, none of it collected by CM, Pinhasi, or Henke. Sources are Persson and Persson (1988) and Constandse-Westermann (unpublished).[3] As noted above, completeness suggests that individuals used in 1998 were from Skateholm I. Data from Bøgebakken, other Vedbæk fjord sites, and Strøby Egede, were collected by CM, while that from Ofnet, Germany, was collected by CM in 1968, with added data from Saller (1962). Other data used are from a number of sites. The full list of sites, dates, and data sources for both analysis sets is given in Table 1.[4] Scandinavian sites are given above, German sites below. In both upper and lower sections, the site sequence is alphabetic, with two exceptions. In the upper list the first site mentioned is Skateholm, placed first because limitations of the full Skateholm database restricted available variables, both in the 1998 and current studies. In the lower list Ofnet individuals are listed first, as Ofnet is the only German site with an appropriate database available from more than two individuals.

As we have noted, the analyses below use Scandinavian and German Mesolithic data to test whether the 1998 conclusions could be verified, especially when data from Strøby Egede adults A and D were compared to data from Skateholm and Bøgebakken, with initial variable choice limited by Skateholm (see note above). A further issue concerns male and female relationships in the principal component and cluster analyses (Johnson & Wichern 2007), knowing that when raw data are used, as in 1998, the first principal component (PC1) always 'explain(s) the maximum amount of variability within the matrix as a linear function of all of the measurements used' (Meiklejohn *et al.* 2012, 285). In practical terms the primary discrimination in PC1 involves size and tends to separate males from females. In practice, analysis using raw measurements should therefore be run separately by sex. Though feasible with a large total sample, it is a major impediment when samples are small, as is the case here, most obvious with the small samples from Strøby Egede, a male and a female, and Skateholm, a male and two females. We therefore corrected for size by applying an allometric transformation to obtain size-adjusted Mosimann shape variables, following Brewster *et al.* (2014a) and Mosimann and James (1979). These were calculated by dividing individual values by the geometric mean of the cranial measurements for that specimen. For similar reasons, we chose to use the Euclidean distance matrix for the size-adjusted rather than the raw data when conducting average-linkage cluster analysis. It is probable that some differences between the results below and those from 1998 are because the earlier study did not apply the allometric transformation. In addition, comment is needed on the overall number of individuals included in the study,

TABLE 1. ANALYSIS (ID) NUMBERS, DATES, & GEOGRAPHIC INFORMATION FOR MESOLITHIC SPECIMENS FROM SCANDINAVIA & GERMANY

| $ID_A$ | $ID_B$ | *Lat* | *Long* | *Site code* | *Specimen* | *Sex* | *Source of data* | *Country* | *Region* | $^{14}$C *cal* BP *(2σ)* |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 55.38 | 13.48 | Sk | Skateholm I - 4 | F | tscw (1987); Persson & Persson (1988) | Sweden | Skåne | (6700–7170)* |
| 2 | 2 | 55.38 | 13.48 | Sk | Skateholm I - 22 | M | tscw (1987); Persson & Persson (1988) | Sweden | Skåne | (6700–7170)* |
| 3 | – | 55.38 | 13.48 | Sk | Skateholm I - 37 | F | tscw (1987); Persson & Persson (1988) | Sweden | Skåne | 6990–7410 |
| 4 | 3 | 59.48 | 5.25 | U | Bleivik 1 | M | Torgersen *et al.* (1953) | Norway | Rogaland | 8480–9120 |
| 5 | 4 | 55.85 | 12.56 | B | Bøgebakken 2 | M | cm (1983/1995); hcp | Denmark | Sjælland | (6400–7230)* |
| 6 | 5 | 55.85 | 12.56 | B | Bøgebakken 3 | M | cm (1983/1995); hcp | Denmark | Sjælland | 6300–7140 |
| 7 | – | 55.85 | 12.56 | B | Bøgebakken 15 | M? | cm (1983/1995); hcp | Denmark | Sjælland | (6400–7230* |
| 8 | 6 | 55.85 | 12.56 | B | Bøgebakken 10 | M? | cm (1983/1995); hcp | Denmark | Sjælland | 6350–7170 |
| 9 | 7 | 55.85 | 12.56 | B | Bøgebakken 22 | F | cm (1983/1995); hcp | Denmark | Sjælland | (6400–7230* |
| 10 | 8 | 56.1 | 14.35 | U | Bäckaskog 1 | F | Rydbeck (1945) | Sweden | Skåne | 8410–8940 |
| 11 | 9 | 55.77 | 11.39 | D | Dragsholm A | F | cm (1983/1995) | Denmark | Sjælland | 6020–7080 |
| 12 | 10 | 55.77 | 11.39 | D | Dragsholm B | F | cm (1983/1995) | Denmark | Sjælland | 6180–7170 |
| 13 | – | 56.4 | 10.71 | U | Fannerup 1 | M | hcp; Maring & Riede 2019 | Denmark | Jylland | 6115–7160 |
| 14 | 11 | 55.4 | 10.13 | U | Koelbjerg 1 | M | tscw (1974); Bröste and Jørgensen (1956) | Denmark | Fyn | 10240–10560 |
| 15 | 12 | 55.35 | 11.16 | U | Korsør Glasværk AS 74-45 | M | cm (1983/1995) | Denmark | Sjælland | 6230–7150 |
| 16 | 13 | 55.35 | 11.16 | K | Korsør Nor 1 | M | cm (1983/1995) | Denmark | Sjælland | 6440–7160 |
| 17 | – | 55.35 | 11.16 | K | Korsør Nor 2 | M? | cm (1983/1995) | Denmark | Sjælland | (6440–7160* |
| 18 | – | 55.93 | 11.98 | U | Melby 1 | M | cm (1983/1995) | Denmark | Sjælland | 6110–7160 |
| 19 | 14 | 55.91 | 11.09 | U | Sejerø 1 | M | cm (1983/1995) | Denmark | Sjælland | 5200–6190 |
| 20 | 15 | 57.8 | 18.53 | U | Stora Bjers 1 | M | tscw (1974) | Sweden | Gotland | 8470–8940 |
| 21 | 16 | 55.41 | 12.24 | St | Strøby Egede A | F | cm (1992) | Denmark | Sjælland | nd |
| 22 | 17 | 55.41 | 12.24 | St | Strøby Egede D | M | cm (1992) | Denmark | Sjælland | nd |
| 23 | 18 | 55.85 | 12.56 | U | Vedbæk-Boldbaner 1 | M | cm (1983/1995) | Denmark | Sjælland | 7360–7960 |
| 24 | 19 | 56.13 | 10.52 | U | Vængesø 2 | M | cm (1978) | Denmark | Jylland | 5370–6300 |
| – | 20 | 48.82 | 10.45 | G | Ofnet 8 (2481 - 4K 1806) | F | cm (1968); Saller (1962) | Germany | Bayern | 8020–8350 |
| – | 21 | 48.82 | 10.45 | G | Ofnet 11 (2484 - 4K 1809) | M | cm (1968); Saller (1962) | Germany | Bayern | (8050–8520* |
| – | 22 | 48.82 | 10.45 | G | Ofnet 13 (2486 - 4K 1811) | F | cm (1968); Saller (1962) | Germany | Bayern | (8050–8520* |
| – | 23 | 48.82 | 10.45 | G | Ofnet 14 (2487 - 4K 1812) | F | cm (1968); Saller (1962) | Germany | Bayern | (8050–8520* |
| – | 24 | 48.82 | 10.45 | G | Ofnet 15 (2488 - 4K 1813) | F | cm (1968); Saller (1962) | Germany | Bayern | (8050–8520* |
| – | 25 | 48.82 | 10.45 | G | Ofnet 18 (2490 - 4K 1815) | F | cm (1968); Saller (1962) | Germany | Bayern | (8050–8520* |
| – | 26 | 48.82 | 10.45 | G | Ofnet 21 (2493 - 4K 1818) | M | cm (1968); Saller (1962) | Germany | Bayern | (8050–8520* |
| – | 27 | 48.82 | 10.45 | G | Ofnet 24 (2496 - 4K 1821) | M | cm (1968); Saller (1962) | Germany | Bayern | (8050–8520* |

(Continued)

Table 1. (Continued)

| $ID_A$ | $ID_B$ | *Lat* | *Long* | *Site code* | *Specimen* | *Sex* | *Source of data* | *Country* | *Region* | *$^{14}C$ cal BP ($2\sigma$)* |
|---|---|---|---|---|---|---|---|---|---|---|
| – | 28 | 48.82 | 10.45 | G | Ofnet 25 (2497 - 4K 1822) | F | cm (1968); Saller (1962) | Germany | Bayern | (8050–8520* |
| – | 29 | 48.82 | 10.45 | G | Ofnet 29 (2501 - 4K 1826) | F | cm (1968); Saller (1962) | Germany | Bayern | (8050–8520* |
| – | 30 | 48.82 | 10.45 | G | Ofnet 32 (2504 - 4K 1829) | F | cm (1968); Saller (1962) | Germany | Bayern | 8050–8590 |
| – | 31 | 51.3 | 12.07 | G | Durrenberg 1 | F | Heberer (1936) | Germany | Sachsen-Anhalt | 8660–9010 |
| – | 32 | 48.55 | 10.17 | G | Hohlenstein im Lonetal 1 | M | cm (1981) | Germany | Bayern | 8430–8980 |
| – | 33 | 48.55 | 10.17 | G | Hohlenstein im Lonetal 2 | F | cm (1981) | Germany | Bayern | (8430–8980* |
| – | 34 | 48.81 | 10.61 | G | Kaufertsberg 1 | M | cm (1968) | Germany | Bayern | nd |

* = site mean

independent of the question on sex-based size differences raised above. The number of individuals included is a factor of preservation conditions and not the choice of using some but not other samples of equal preservation. In addition, choices were dependent on the condition of preservation of the remains recovered from the three primary archaeological sites being compared. Crania with remains insufficiently complete for purposes of comparison were automatically excluded. Finally, we did not replace missing values in incomplete crania, since such replacement is based on the assumption that such values fit a normative curve in the overall sample, thereby potentially reducing the total variation.

Finally, for this section, two further comments are needed. The first pertains to calibration of the radiocarbon dates. We have used the Intcal20 Northern Hemisphere calibration curve (Reimer *et al*. 2020), replacing the previous Intcal13. The result includes changes to age spread of dates following calibration. All calibrated dates involved use of CALIB version 8.2. Dates therefore will vary from those published with Intcal13. The second relates to correction for $\delta^{13}C$ values in the calibration, with two clarifications needed. $\delta^{13}C$ endpoints used for Danish and Swedish material are -10.5‰ and -25.0‰, follow Kaare Lund Rasmussen (pers. comm.). In addition, the delta R values used for Denmark and Sweden are -74±232 and -280±57 respectively, following the regional tables in CALIB revision 8.2 (http:/calib.org/marine; see also Stuiver & Reimer 1993).

### *Analysis set A*

Analysis set A most closely replicates the 1998 results, using the same five variables and 24 Scandinavian individuals, 18 from Denmark, five from Sweden, and one from Norway (see Table 1 with raw data in Table 3). Choice of variables is limited to those available for Skateholm, as already noted. The central site grouping comprises the following individuals: Strøby Egede individuals A and D; Bøgebakken 2, 3, 10, 15, and 22; and Skateholm I-4, I-22, and I-37 (Table 1). Variables used are a mix from vault and face, maximum cranial length (M1/GOL), maximum cranial breadth (M8/XCB), maximum frontal breadth (M10/XFB), bizygomatic breadth (M45/ZYB), and nasal breadth (M54/NLB). Measurements used are similarly defined by Martin and Saller (1957) (M1,



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TABLE 2. SUMMARY OF PCA FOR SCANDINAVIAN DATA ON M1, M8, M10, M45, & M54 (N=24). PCA ON THE COVARIANCE MATRIX OF THE SIZE ADJUSTED CRANIAL MEASUREMENTS

| | *PC1* | *PC2* | *PC3* |
|---|---|---|---|
| Standard deviation | 0.07057 | 0.05054 | 0.03878 |
| Eigenvalue | 0.00498 | 0.00255 | 0.00150 |
| Proportion of variance | 0.494 | 0.253 | 0.149 |
| Cumulative proportion | 0.494 | 0.748 | 0.897 |

| | *Coefficients of first three PCs* | | | *Correlations with PC scores* | | |
|---|---|---|---|---|---|---|
| *Cranial measurement* | *PC1* | *PC2* | *PC3* | *PC1* | *PC2* | *PC3* |
| M1 = Greatest length | -0.917 | -0.238 | 0.284 | -0.969 | -0.180 | 0.165 |
| M8 = Max. cranial breadth | 0.295 | -0.366 | 0.360 | 0.517 | -0.460 | 0.347 |
| M10 = Max. frontal breadth | 0.261 | -0.575 | 0.444 | 0.427 | -0.673 | 0.399 |
| M45 = Bizygomatic breadth | -0.052 | -0.616 | -0.768 | -0.084 | -0.719 | -0.688 |
| M54 = Nasal breadth | 0.025 | 0.316 | -0.057 | 0.109 | 0.982 | -0.137 |

PC1 is a weighted contrast of M1 vs M8 & M10
PC2 is a weighted contrast of M54 vs M8, M10, & M45
PC3 is a weighted contrast of M45 vs M8 & M10

M8, M10, M45, & M54) and Howells (1973) (GOL, XCB, XFB, ZYB, & NLB).

Principal component analysis (PCA) was conducted on the sample covariance matrix of the size-adjusted Mosimann shape variables. The first three principal components account for 89.7% of total variance: 49.4% for component 1 (PC1), 25.3% for component 2 (PC2), and 14.9% for component 3 (PC3) (for summary see Table 2).

Figure 1 is a scatterplot of PC2 vs PC1 scores, with points labelled by specimen identification (ID) numbers and plotting symbols for selected site groups. Site groups are: B=Bøgebakken; D=Dragsholm; K=Korsør; Sk=Skateholm; St=Strøby Egede; and U=unspecified except by number (see Table 1, column A; $ID_A$). Individual numbers in the text (see below) refer to sites and individuals listed in Table 1 and identified in Figure 1. The latter shows a red convex hull outlining the Bøgebakken individuals (5–9); clearly evident is the spread on PC1, covering *c*. 75% of the total dispersion in that direction. The full plot shows only one further clear site grouping, three males from western Sjælland, Kørsor Nor 1 and 2 (16 & 17), and Korsør Glasværk AS 74-45 (15). Further to PC1, all but four individuals lie within the Bøgebakken range, including all from Strøby Egede, Dragsholm, and Skateholm. Outliers are Koelbjerg (14), Korsør Nor 1 (16), and Vedbæk-Boldbaner (23), all Danish, and Stora Bjers (20) from central Sweden. Note that Koelbjerg, the most marked outlier, is the earliest individual in the analysis by *c*. 1500 years, based on median radiocarbon dates. In addition, the consistent separation of Koelbjerg and the youngest individual, Sejerø (19; also referred to in various sources as Rødhals or Sejerø/Rødhals), from other individuals in the PC plots shows the analysis as sufficiently robust to detect outliers.

On PC2 the narrower spread for Bøgebakken in the middle of the range is clear, as is separation from most other individuals in analysis A. Only six lie within the Bøgebakken range, two obviously, the Skateholm I-37 (3) and Dragsholm A (11) females, and four marginally, the three Korsør males (15–17) and Vedbæk-Boldbaner (23). For this paper, most interesting is that both Strøby Egede A and D (21 & 22), though themselves separated, and the other two Skateholm individuals (1 & 2), lie outside the Bøgebakken range.

However, in further considering Figure 1, note that the Bøgebakken spread on PC1 is 'highly inflated' by the position of Bøgebakken 3 (6), an outlier to all other individuals on this axis. The range for the other four Bøgebakken individuals is almost identical to the three from Skateholm (1–3) and Strøby Egede D (22), though Strøby Egede A (21) is an outlier in the same direction as Bøgebakken 3. That the latter is the principal outlier on PC1 can be interpreted by knowledge that PC1 is a weighted contrast between M1 vs M8 and M10 (Table 2); in other words, between cranial length and cranial breadth. The raw data (Table 3) show Bøgebakken 3 as the most

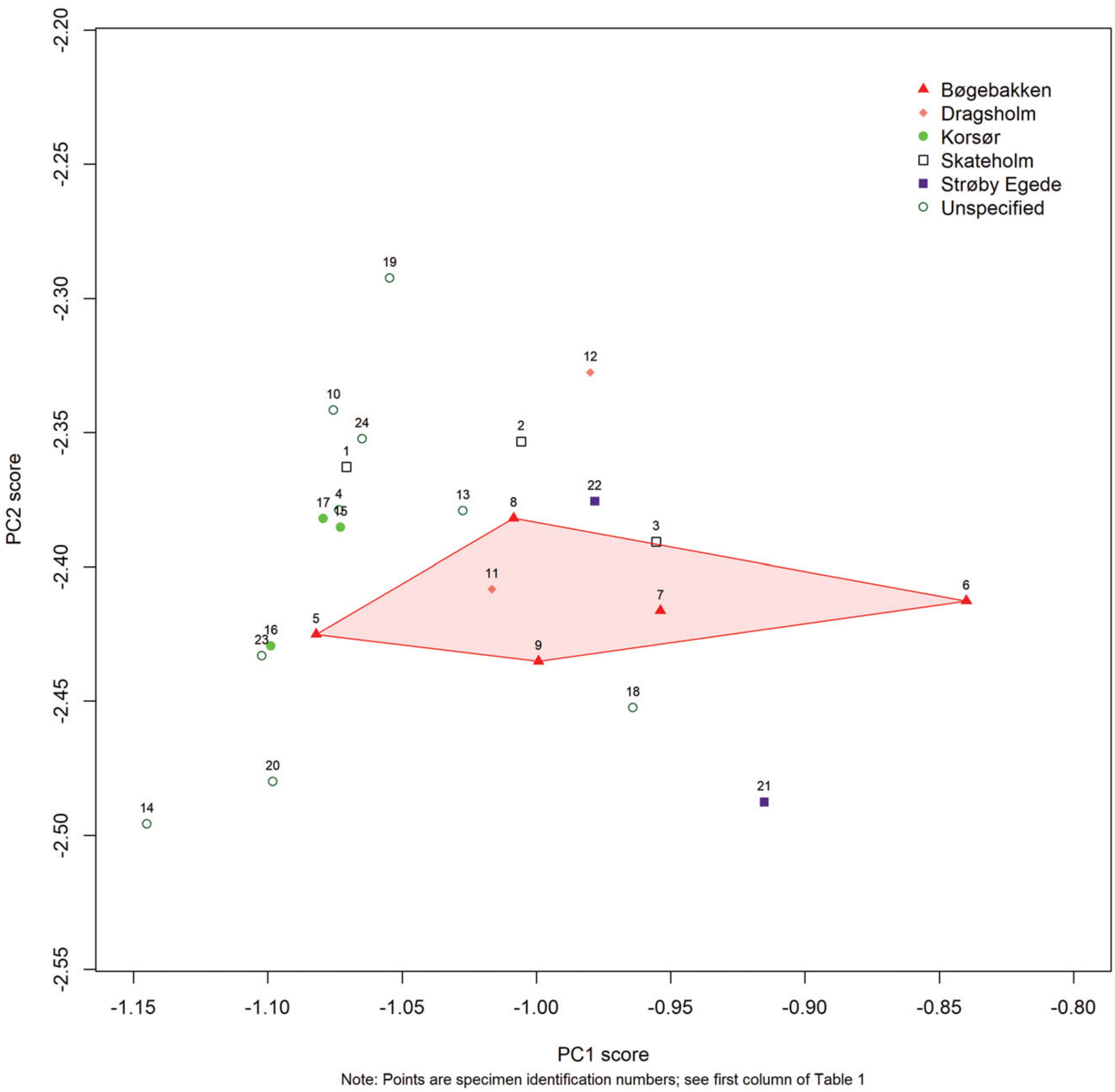


Fig. 1.
PC2 vs PC1 scores for size adjusted Scandinavian data (n = 24, 5 variables, PCA on S) with site indicated & convex hull for Bøgebakken individuals

brachycephalic (broad-headed) of the series with a cranial index (100 × M8/M1) of 89.8. The closest three individuals by PC1 score are Strøby Egede A (21), Bøgebakken 15 (7), and Skateholm 1-37 (3), with indices of 84.0, 79.7, and 82.3, clearly predictable from the importance of the cranial index to the weighted contrast noted above. Individuals most separated on the PC2 score range are Sejerø (19), the most recent with the highest PC2 score, and Koelbjerg (14), the earliest with the lowest.

Figure 2, a scatterplot of PC3 vs PC2 scores, is labelled as in Figure 1, with the red convex hull again



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TABLE 3. RAW DATA FOR INDIVIDUALS USED IN ANALYSES A & B

| $ID_A$ | $ID_B$ | *Site/ area code* | *Specimen* | *Sex* | *M1* | *M8* | *M9* | *M10* | *M12* | *M29* | *M30* | *M45* | *M54* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Sk | Skateholm I - 4 | F | 187 | 136 | 102 | 113 | 108 | 112 | 116 | 144 | 26 |
| 2 | 2 | Sk | Skateholm I - 22 | M | 193 | 147 | 106 | 123 | 130 | 114 | 114 | 150 | 28 |
| 3 | – | Sk | Skateholm I - 37 | F | 175 | 144 | 96 | 115 | – | 106 | 107 | 135 | 24 |
| 4 | 3 | U | Bleivik 1 | M | 184 | 184 | 91 | 110 | 104 | 113 | 117 | 135 | 24 |
| 5 | 4 | B | Bøgebakken 2 | M | 189 | 141 | 96 | 116 | 105 | 110 | 114 | 140 | 23 |
| 6 | 5 | B | Bøgebakken 3 | M | 167 | 150 | 96 | 117 | 114 | 112 | 97 | 148 | 25 |
| 7 | – | B | Bøgebakken 15 | M? | 197 | 157 | 98 | 125 | – | 115 | 129 | 143 | 26 |
| 8 | 6 | B | Bøgebakken 10 | M? | 201 | 164 | 111 | 134 | 144 | 125 | 117 | 160 | 27 |
| 9 | 7 | B | Bøgebakken 22 | F | 177 | 142 | 94 | 115 | 112 | 103 | 108 | 134 | 22 |
| 10 | 8 | U | Bäckaskog 1 | F | 182 | 136 | 94 | 108 | 107 | 108 | 112 | 131 | 25 |
| 11 | 9 | D | Dragsholm A | F | 169 | 135 | 88 | 104 | 103 | 94 | 95 | 131 | 22 |
| 12 | 10 | D | Dragsholm B | F | 180 | 141 | 1o3 | 116 | 109 | 105 | 113 | 136 | 27 |
| 13 | – | U | Fannerup 1 | M | 181 | 143 | 96 | 107 | 111 | 113 | – | 144 | 25 |
| 14 | 11 | U | Koelbjerg 1 | M | 191 | 141 | 101 | 113 | 110 | 107 | 123 | 139 | 20 |
| 15 | 12 | U | Korsør Glasværk AS 74-45 | M | 191 | 141 | 103 | 117 | 120 | 110 | 125 | 142 | 25 |
| 16 | 13 | K | Korsør Nor 1 | M | 197 | 146 | 106 | 117 | 114 | 114 | 111 | 150 | 24 |
| 17 | – | K | Korsør Nor 2 | M? | 189 | 138 | 102 | 115 | 120 | 112 | – | 142 | 25 |
| 18 | – | U | Melby 1 | M | 180 | 141 | 101 | 126 | 113 | – | – | 143 | 23 |
| 19 | 14 | U | Sejerø 1 | M | 194 | 145 | 97 | 116 | 118 | 123 | 116 | 138 | 29 |
| 20 | 15 | U | Store Bjers 1 | M | 191 | 139 | 103 | 118 | 109 | 110 | 120 | 150 | 22 |
| 21 | 16 | St | Strøby Egede A | F | 187 | 157 | 108 | 134 | 121 | 115 | 111 | 151 | 23 |
| 22 | 17 | St | Strøby Egede D | M | 187 | 148 | 106 | 123 | 112 | 112 | 116 | 142 | 26 |
| 23 | 18 | U | Vedbæk-Boldbaner 1 | M | 198 | 144 | 102 | 120 | 105 | 122 | 123 | 150 | 24 |
| 24 | 19 | U | Vængesø 2 | M | 187 | 140 | 101 | 111 | 111 | 105 | 120 | 141 | 26 |
| – | 20 | G | Ofnet 8 (2481 - 4K 1806) | F | 181 | 146 | 93 | 117 | 115 | 103 | 117 | 130 | 25 |
| – | 21 | G | Ofnet 11 (2484 - 4K 1809) | M | 186 | 145 | 100 | 116 | 106 | 107 | 120 | 136 | 28 |
| – | 22 | G | Ofnet 13 (2486 - 4K 1811) | F | 185 | 132 | 91 | 108 | 112 | 111 | 118 | 121 | 23 |
| – | 23 | G | Ofnet 14 (2487 - 4K 1812) | F | 190 | 136 | 96 | 126 | 105 | 106 | 124 | 124 | 24 |
| – | 24 | G | Ofnet 15 (2488 - 4K 1813) | F | 180 | 142 | 90 | 116 | 113 | 109 | 105 | 124 | 24 |
| – | 25 | G | Ofnet 18 (2490 - 4K 1815) | F | 181 | 141 | 95 | 119 | 105 | 105 | 116 | 133 | 22 |
| – | 26 | G | Ofnet 21 (2493 - 4K 1818) | M | 205 | 133 | 98 | 111 | 105 | 115 | 132 | 132 | 26 |
| – | 27 | G | Ofnet 24 (2496 - 4K 1821) | M | 184 | 139 | 103 | 124 | 114 | 104 | 109 | 138 | 25 |
| – | 28 | G | Ofnet 25 (2497 - 4K 1822) | F | 178 | 135 | 93 | 109 | 110 | 116 | 114 | 133 | 24 |
| – | 29 | G | Ofnet 29 (2501 - 4K 1826) | F | 177 | 138 | 90 | 103 | 111 | 106 | 105 | 125 | 26 |
| – | 30 | G | Ofnet 32 (2504 - 4K 1829) | F | 180 | 136 | 92 | 111 | 112 | 113 | 115 | 128 | 24 |
| – | 31 | G | Durrenberg 1 | F | 180 | 139 | 89 | 112 | 114 | 106 | 111 | 135 | 24 |
| – | 32 | G | Hohlenstein in Lonetal 1 | M | 185 | 143 | 92 | 123 | 111 | 111 | 127 | 136 | 26 |
| – | 33 | G | Hohlenstein in Lonetal 2 | F | 176 | 134 | 88 | 112 | 108 | 103 | 118 | 122 | 22 |
| – | 34 | G | Kaufertsberg 1 | M | 184 | 142 | 94 | 121 | 116 | 121 | 114 | 138 | 24 |

delineating Bøgebakken individuals. The PC2 horizontal spread is as in Figure 1, with the male, Sejerø (19), most obviously separated. PC3 shows all other individuals lying within the Bøgebakken range when individual 3 (6) is included.

Cluster analysis using average linkage on the Euclidean distance matrix for the same size-adjusted dataset is similar in pattern. The dendrogram (Fig. 3) has a cophenetic correlation value[5] of 0.785 (see Sneath & Sokal 1973; Romesberg 1984). As expected from the analysis above, principal outliers are Bøgebakken 3 (6) and Koelbjerg (14). The remaining material separates into two major clusters, with the smaller also the tightest in terms of relatedness. In addition, we note that only two site groups are bundled within a single major cluster, Strøby Egede A and D (21 & 22) within the smaller, and the three Korsør males (15–17) within the larger.

The smaller red cluster, with nine individuals, is more clearly linked in site and geographic terms, with six from eastern Sjælland, the two from Strøby Egede (21 & 22), three of five from Bøgebakken (7–9), and



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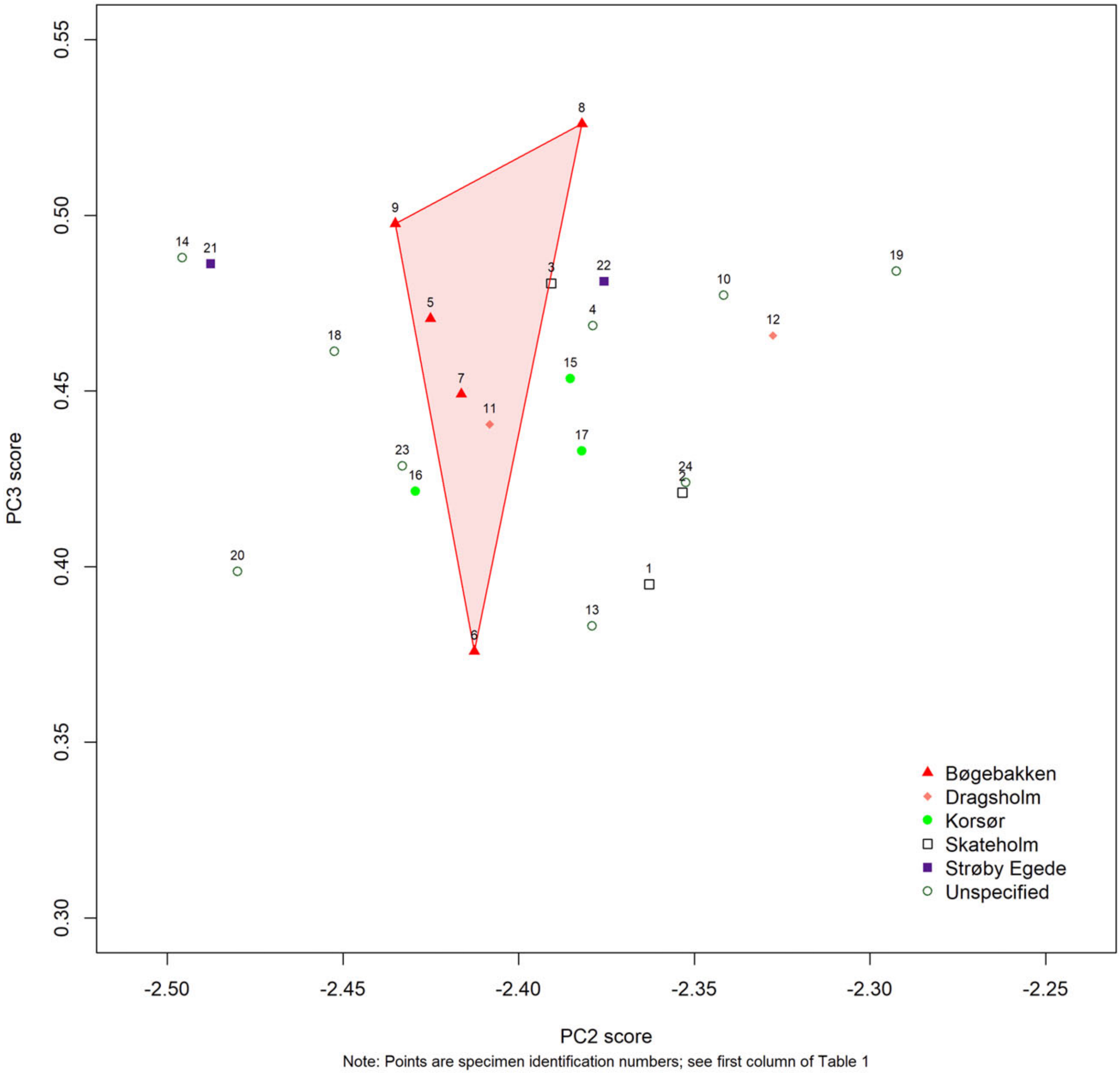


Fig. 2.
PC3 vs PC2 scores for size adjusted Scandinavian data (n = 24, 5 variables, PCA on S) with site indicated & convex hull for Bøgebakken individuals

the male from Melby (18), north-west of Bøgebakken. Two of the other three individuals are from Skateholm (2 & 3), from Skåne, clearly linking sites on the Øresund in eastern Sjælland with Skateholm on the south-west Swedish coast. The last, Dragsholm B (12) from north-west Sjælland to the west, becomes an obvious geographic outlier.

The larger and looser blue cluster of 13 individuals is harder to interpret, though containing some geographically linked material. Most obvious are seven individuals from north-western Sjælland and eastern Jylland, opposite sides of the strait linking the northern Storebælt and the southern Kattegat. On the Sjælland side are Dragsholm A (11), the three Korsør

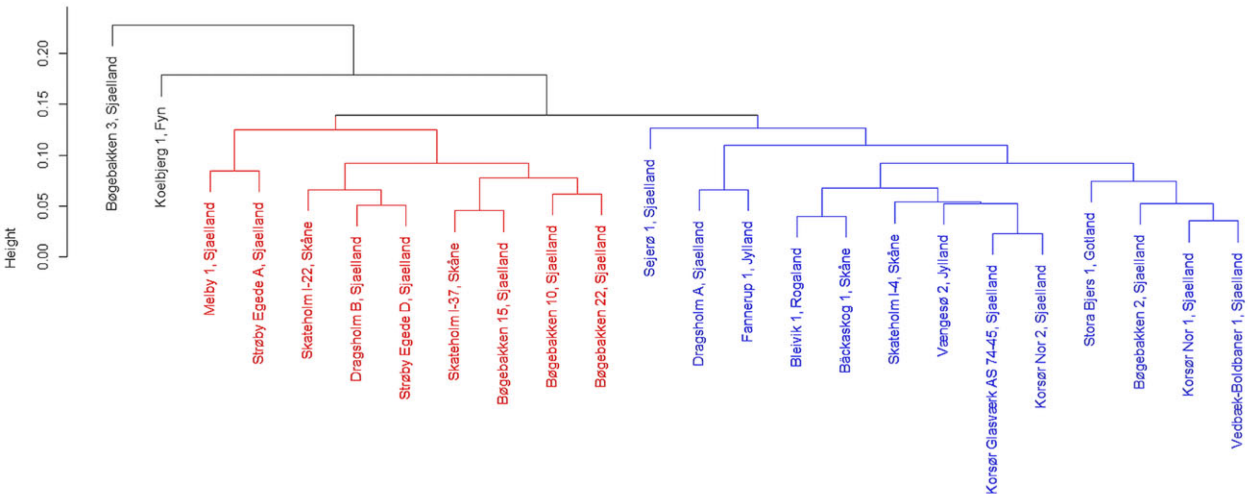


Fig. 3.
Cluster analysis on size adjusted Scandinavian data (n = 24, 5 variables), method = average linkage, rcoph = 0.785, with specimens and regions indicated

individuals (15–17), and Sejerø (19), the late chronological outlier. Jylland individuals are the only two available from this area, Fannerup 1 (13) and Vængesø 2 (24). The other six lack obvious geographic links. Three are geographic outliers to the smaller, tighter, cluster, Bøgebakken 2 (5), Skateholm I-4 (1), and Vedbæk-Boldbaner (23). Note that Vedbæk-Boldbaner does not tend to cluster with Bøgebakken, though both are from the Vedbæk fjord. This may relate to their ages, with Vedbæk-Boldbaner *c.* 900 years older than the Bøgebakken series mean. The other three are from Sweden, Stora Bjers in Gotland (20), Bäckaskog in Skåne (10) and western Norway, Bleivik (4). Interestingly, Bäckaskog and Bleivik, among the furthest apart geographically, consistently cluster together, possibly suggesting a certain homogeneity across the whole Scandinavian data set.

Summarising the five-variable analysis, both PCA and cluster analysis link Strøby Egede, Bøgebakken, and Skateholm. Though patterns exist, they do not separate these three sites. At the same time the pattern does not support unpublished work by CM from the 1980s suggesting that Bøgebakken was more heterogeneous than other Mesolithic series. The reason is unclear and may reflect differences in statistical approaches. The earlier work employed canonical analysis and used raw metric data rather than the allometric transformation used here (see above). The overlap noted above suggests that individuals in eastern Sjælland and south-western Skåne were closely related, with only three apparent exceptions, Vedbæk-Boldbaner (23), and Bøgebakken 2 (5) and 3 (6). The first might be expected to align with Bøgebakken in the tighter major cluster, with both from the same fjord. However, Vedbæk-Boldbaner is considerably older, as noted above. Of the other two, Bøgebakken 2 (5) aligns with western Sjælland and Jylland individuals in the loose major cluster, with Bøgebakken 3 (6) a total outlier. Analysis A suggests a possible divide between groups in eastern Sjælland and south-western Skåne and those in western Sjælland and Jylland. Within this model Bøgebakken 2 could be an outsider from the west. The more extreme isolation of Bøgebakken 3 is harder to fit and is currently enigmatic. Linkage of all three individuals from outside the Strøby Egede/Bøgebakken/Skateholm group into a single major cluster also remains enigmatic. Linkage of Stora Bjers and Bäckaskog to Skateholm 'makes sense', linking material from Skåne and Gotland but requiring more data. We do not, for example, have craniometric data from Mesolithic individuals from the Stora Förvar series on Gotland. Finally, we stress that Analysis set A clearly contradicts the 1998 suggestion that Strøby Egede individuals are morphologically separated from Bøgebakken but linked to Skateholm.



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*Analysis set B*

Analysis set A was framed as examining data used to suggest that lithic groups defined by Vang Petersen (1984) for Ertebølle period Sjælland might also define biologically separate groups. As explained above, limitations in the 1998 analysis lay in part within the quality of available data, especially from poorly preserved Skateholm. This initial analysis set was designed, insofar as possible, to replicate the 1998 study. Analysis set B tries to expand from those limitations in two ways, first by increasing the number of variables used and, secondly, by expanding geographic coverage. At the same time, we look at questions raised in set A, including whether we might be able to say more about individuals in the first analysis that were geographically close but acted as statistical outliers.

Analysis set A identified the Bøgebakken 3 male (6) and Strøby Egede A female (21) as outliers on the right-hand side of the PC1 axis in the PC1 vs PC2 scatterplot (Fig. 1). An obvious question is whether both had an origin outside the geographic area sampled, perhaps to the south? We therefore decided to look at the relationship of individuals in analysis A to data from Mesolithic sites south of the western Baltic. This was restricted to German data, with none available from Poland. We also looked at more variables, to assure that the limited number in set A gave a reasonable picture of the morphology of the individuals studied. Expansion of the number to nine, *per force*, reduced the number of individuals included in set A due to preservation issues, with five removed, Skateholm I-37, Bøgebakken 15, Fannerup 1, Korsør Nor 2, and Melby. The five variables used in Analysis 1 were retained and we added frontal and parietal cranial chords (M29/FRC, M30/PAC) and two breadth measurements, minimum frontal (M9/WFB) and biasterionic (M12/ASB). This resulted in 19 Scandinavian and 15 German individuals, though unfortunately with only one from northern Germany, Dürrenberg in Sachsen-Anhalt. The other 14 are from three sites: two from Hohlestein im Lonetal in the Swabian Jura (Baden-Württemberg) and the others from Bavaria: one from Kaufertsberg and 11 from Ofnet (Große Ofnethöhle). Analyses are as in set A, ie, based on size-adjusted data.

The first three principal components account for 73.3% of total variance: 41.4% for PC1, 18.8% for PC2, and 13.1% for PC3 (Table 4). Figure 4, a scatterplot of PC2 vs PC1 scores, has points labelled by specimen identification numbers and plotting symbols for selected site groups. Identified site groups are labeled as for Analysis A with the addition of Ge=Germany (see Table 1, column B; $ID_B$). Convex hulls are shown for the four Bøgebakken (in solid red; 4–7) and 15 German individuals (in dashed blue; 20–34). They show strong separation, with the exception that the Ofnet 24 male (27) lies within the Bøgebakken hull, as do both Strøby Egede specimens (16 & 17), Dragsholm B (10), and Skateholm I-22 (2). Skateholm I-4 (1) and Vængesø 2 (19) are outside it, but near to Bøgebakken 2 (4).

The German individuals have generally higher scores on both the PC1 and PC2 axes. Only four of 19 Scandinavian specimens lie within the German convex hull: the Norwegian male Bleivik 1 (3), the Swedish female Bäckaskog 1 (8), and two Danish males, Korsør Glasværk AS 74-45 (12) and Sejerø (14). Strøby Egede D (the male, 17), Dragsholm B (10), and Bøgebakken 22 (7) lie outside the German hull, but are close to Ofnet 24 (27), itself an outlier within the German series. Finally, no obvious linkage is seen on PC1 for three Ofnet individuals that are outliers on the right-hand side of the axis, two females (22 & 23) and a male (26).

PC3 vs PC1 and PC3 vs PC2 scatterplots were generated but are not presented here. They were less informative, other than demonstrating that the Sejerø male (14) had the highest value on the PC3 axis. Outside the main focus of this paper, Sejerø is the youngest individual in the study by *c*. 170 years. None of our analyses provides obvious insight into affinities of this individual, understood as from a still independent Mesolithic group post-dating the earliest Neolithic settlers in Denmark (Bennike & Alexandersen 1997; Brinch Petersen & Meiklejohn 2009). The associated cluster analysis confirms the complexity of the PCA findings. The dendrogram (Fig. 5) has a cophenetic correlation value of 0.716, slightly lower than for Analysis A. Ofnet 21 (26) is a clear outlier as are, to a lesser extent, Bøgebakken 3 (5), Ofnet 13 (22), and Ofnet 14 (23).

The clustering pattern is far more complex, with up to ten sub-clusters, especially with internal outliers included, individuals attached at some distance to a larger sub-cluster. A more loosely identified set includes 4–6 sub-clusters. Focusing on a four-cluster solution, Scandinavian and German datasets overlap

TABLE 4. SUMMARY OF PCA FOR SCANDINAVIAN & GERMAN DATA ON 9 VARIABLES (N = 34). PCA ON THE COVARIANCE MATRIX OF THE SIZE ADJUSTED CRANIAL MEASUREMENTS

| | *PC1* | *PC2* | *PC3* | *PC4* | *PC5* | *PC6* | *PC7* | *PC8* | *PC9* |
|---|---|---|---|---|---|---|---|---|---|
| Standard deviation | 0.09190 | 0.06185 | 0.05160 | 0.03922 | 0.03780 | 0.03433 | 0.03115 | 0.01813 | 0.00103 |
| Eigenvalue | 0.00845 | 0.00383 | 0.00266 | 0.00154 | 0.00143 | 0.00118 | 0.00097 | 0.00033 | 0.00000 |
| Proportion of variance | 0.414 | 0.188 | 0.131 | 0.075 | 0.070 | 0.058 | 0.048 | 0.016 | 0.000 |
| Cumulative proportion | 0.414 | 0.602 | 0.733 | 0.808 | 0.878 | 0.936 | 0.984 | 1.000 | 1.000 |

| | *Coefficients of first three PCs* | | | *Correlations with PC scores* | | |
|---|---|---|---|---|---|---|
| *Cranial measurement* | *PC1* | *PC2* | *PC3* | *PC1* | *PC2* | *PC3* |
| M1 = Greatest length | 0.516 | −0.130 | 0.132 | 0.828 | −0.140 | 0.119 |
| M8 = Max. cranial breadth | −0.309 | 0.071 | −0.253 | −0.667 | 0.103 | −0.306 |
| M9 = Min. frontal breadth | −0.079 | −0.397 | −0.061 | −0.210 | −0.708 | −0.091 |
| M10 = Max. frontal breadth | −0.155 | 0.027 | −0.676 | −0.316 | 0.037 | −0.775 |
| M12 = Biasteronic breadth | −0.337 | 0.495 | 0.159 | −0.601 | 0.595 | 0.160 |
| M29 = Frontal chord | 0.179 | 0.201 | 0.493 | 0.377 | 0.285 | 0.583 |
| M30 = Parietal chord | 0.597 | −0.069 | −0.352 | 0.877 | −0.069 | −0.290 |
| M45 = Bizygomatic breadth | −0.324 | −0.722 | 0.249 | −0.516 | −0.775 | 0.223 |
| M54 = Nasal breadth | 0.004 | 0.088 | 0.068 | 0.022 | 0.339 | 0.218 |

PC1 is a weighted contrast of M1 & M30 vs M8, M12, & M45
PC2 is a weighted contrast of M9 & M45 vs M12
PC3 is a weighted contrast of M10 & M30 vs M29

in the two central clusters, while the smaller third and fourth are regionally limited. The right-hand cluster (green), with five individuals, links the Strøby Egede/Bøgebakken/Skateholm group of Analysis set A with Dragsholm added. The three males are Skateholm I-22 (2) and Bøgebakken 3 and 10 (5 & 6), while the two females are Strøby Egede A (16) and Dragsholm A (9). However, other individuals from these sites are spread through the two larger mixed sub-clusters, and Bøgebakken 3, a conspicuous outlier in Analysis set A, is now part of the five individual Scandinavian set. In a similar fashion, the left-hand cluster (red) contains only German individuals, two females from Ofnet (23 and 25) and the Hohlestein im Lonetal male and female (32 & 33). Finally, comment is also needed on Ofnet 21 (26), outlier to all other individuals at the upper left of Figure 5. A cluster analysis without this individual (not published here) did not alter relationships between remaining individuals in the dataset.

Returning to the two central clusters (blue, purple) with both Scandinavian and German individuals, each contains 12. The more interpretable, to the left in Figure 5 (blue), has two individuals from Ofnet (21 & 27), Strøby Egede D (17), and Dragsholm B (10). The remaining eight include two from western Sjælland, the Korsør pair (12 & 13), and the single Jylland individual, Vængesø 2 (19), with 12 and 19 linked as a pair. There is therefore some similarity to the western Denmark group in Analysis A, especially with Dragsholm B included, though balanced somewhat by presence of Strøby Egede D (17), Bøgebakken 2 (4), and Skateholm I-4 (1) from the Strøby Egede/Bøgebakken/Skateholm group. The final three in this cluster are all apparent 'wanderers', sites whose behaviour in both analyses is difficult to interpret. Perhaps most obvious is Koelbjerg (11), most likely related to its position as a chronological outlier, the oldest in the dataset (see above). The other two, Vedbæk-Boldbaner (18) and Stora Bjers (15), together with a link through Skateholm I-4 (1), may suggest a tie within Sweden for Stora Bjers and Skateholm I-4. This leaves Vedbæk-Boldbaner, though Bøgebakken 2 is close by. The general distance of Vedbæk-Boldbaner from the Bøgebakken individuals raises the issue of whether there was at least some population shift in the roughly 900 years between the dates for Vedbæk-Boldbaner (~7660 BP) and the Bøgebakken mean (~6785 BP). Local evolution is also a possibility.

Finally, the second mixed cluster (purple) again raises the comment that overall separation of identifiable regional groups in Scandinavia and Germany may be limited. Eight of 12 individuals are German,



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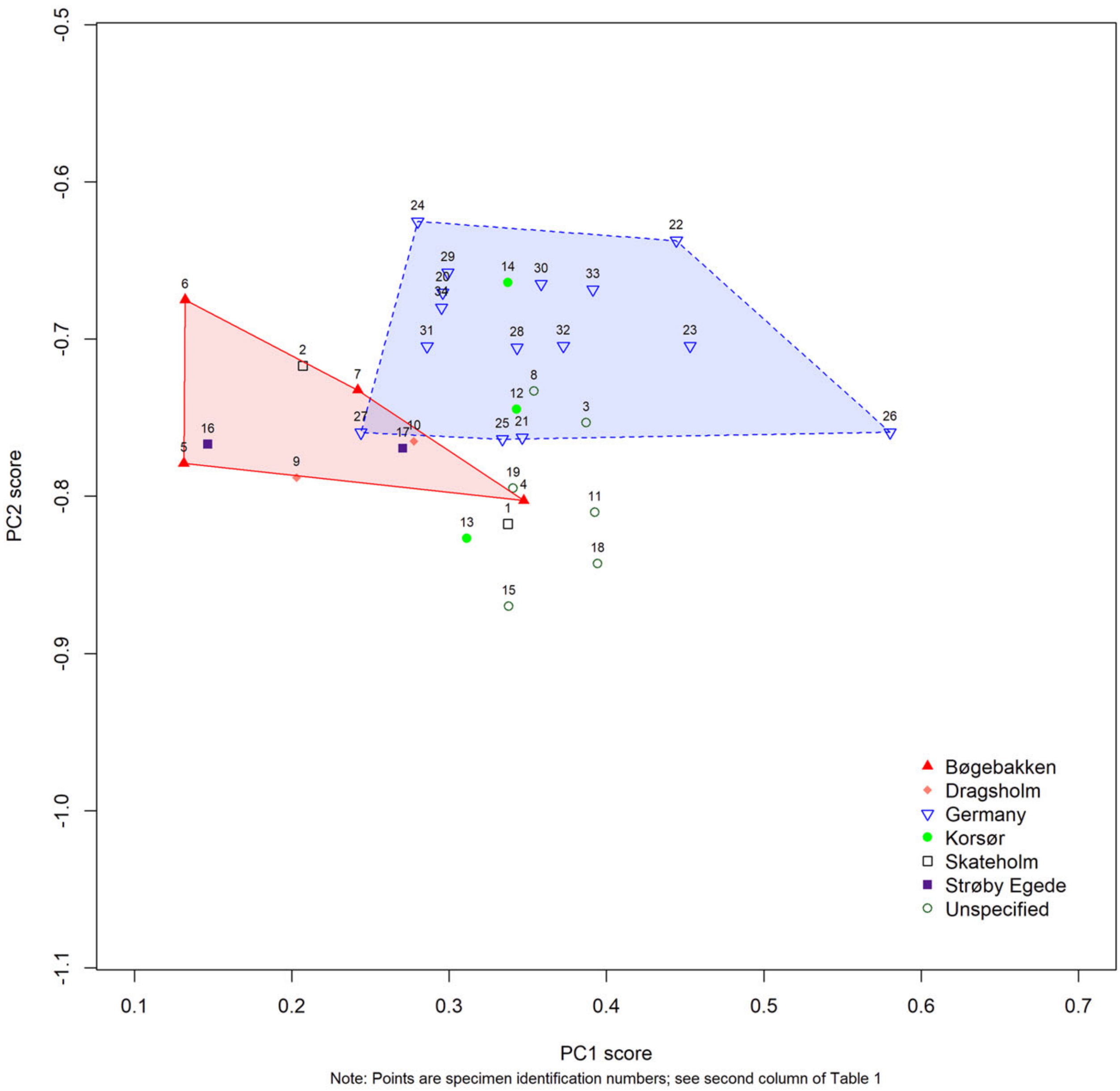


Fig. 4.
PC2 vs PC1 scores for size adjusted Scandinavian data (n = 34, 9 variables, PCA on S) with site indicated & convex hull for Bøgebakken and German individuals

six from Ofnet plus Kaufertsberg (34) and Dürrenberg (31). Interestingly, Dürrenberg, the only north German individual in the sample, is closest to Bøgebakken 22 (7). The overall pattern is unclear. The other three non-German individuals, Bleivik (3), Bäckaskog (8), and Sejerø (14) are, again, 'wanderers'. Bleivik and Bäckaskog pair in both analyses, A and B, as an 'odd couple' linking western Norway and central Sweden. With no obvious linkage to other Swedish individuals included here, the one apparent association is their roughly identical ages, 8800 and 8675 BP. Finally, Sejerø (14) remains enigmatic. Clearly the youngest individual in the analyses, at 5680 BP, and lying at the margins in some of the Principal



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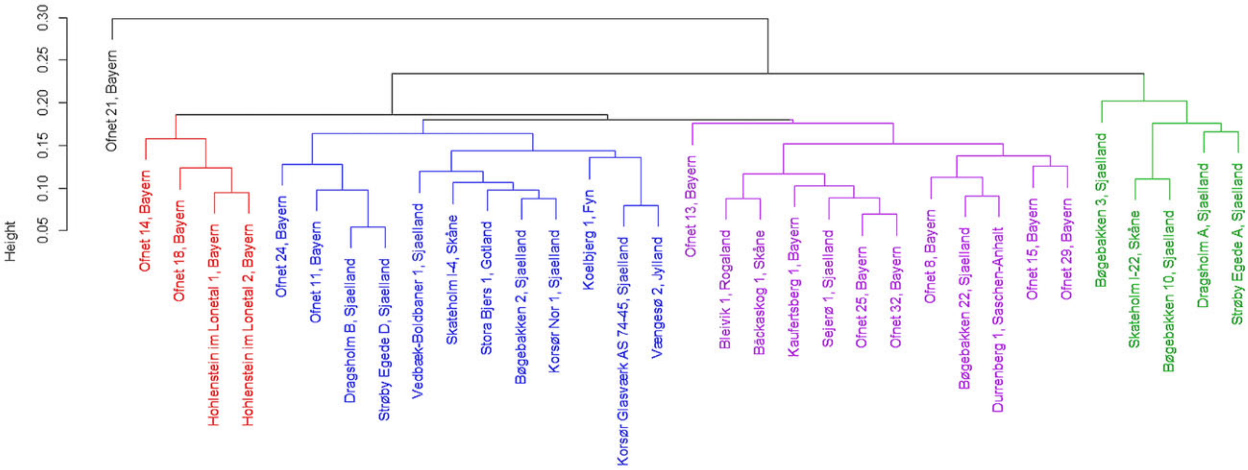


Fig. 5.
Cluster analysis on size adjusted Scandinavian and German data (n = 34, 9 variables), method = average linkage, rcoph = 0.716, with specimens and regions indicated

Component axes (see above), closest neighbours are two Ofnet females (28 & 30).

## CONCLUSION

This paper revisits the 1998 suggestion that individuals from Strøby Egede in south-eastern Sjælland might be morphologically closer to those from Skateholm in southern Skåne, Sweden, *c.* 70 km to the east, than to Bøgebakken, also in eastern Sjælland, *c.* 50 km to the north. The primary limitation in 1998 lay in limited data availability for the Strøby Egede and Skateholm series, the first related to its display at Køge Museum when measured in 1992, the second to poor preservation. As a result, choice of variables rested on availability rather than morphology, as would be possible in a collection of complete skeletons. Beyond these factors, further comparisons were limited by lack of publication of appropriate data.

The above aside, our clearest conclusion is that the new analysis does *not* support the earlier suggestion that Strøby Egede adults A and D were morphologically more similar to individuals from Skateholm than from Bøgebakken, a model that appeared to fit lithic styles described by Vang Petersen (1984). Rather, the new analysis supports the morphological similarity of the three series, suggesting that local groups in eastern Sjælland and southern Skåne were biologically and culturally integrated during the Ertebølle. Within such a system most 'marriages' and, by extension, the pattern of gene flow, would remain within the larger amorphous population. Though clearly within a different ecological framework, similar patterns have been demonstrated ethnographically in boreal forest hunter-gatherers in Canada and Alaska (Meiklejohn 1977; Roth 1981).

Beyond demonstrating a Strøby Egede/Bøgebakken/Skateholm linkage, our analyses provide a less clear picture for surrounding areas. For example, is this grouping matched elsewhere? Analysis set A suggests possible linkage between western Sjælland and eastern Jylland. However, only a limited site group was available, three individuals from Korsør and single skeletons from Vængesø and Fannerup, all used in set A but with only Korsør and Vængesø available in set B. The Dragsholm females, from western Sjælland, might have been expected to cluster here, but the two analysis sets show irregular linkage to west and east. So might the individual from Sejerø, a consistent 'wanderer' in the analyses, and also chronologically later. Presence of separate eastern and west/central Danish 'populations' must therefore remain moot, with more data needed.

Addition of German material in Analysis set B was initially framed by the question of whether apparent outliers in set A might be incomers from south of the Baltic. However, as discussed, only one individual with complementary data, Dürrenberg, was from northern Germany. No outlying Scandinavian



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individuals in analysis A showed obvious linkage to the available German sample. However, the clear overlap of the PC1 distribution between German and Scandinavian individuals could argue for a partially integrated rather than clearly separated population over the total area, with apparently smaller Ofnet and larger Scandinavian individuals sitting at opposite poles in an isolation by distance model. This, however, remains to be proven given the limitations in the current available data.

A further issue is chronological divergence. To what degree do apparent outliers reflect temporal difference, including possible group movement? The obvious outliers, Koelbjerg at 10,385 BP and Sejerø at 5680 BP, differ in age by *c.* 4700 years. Both act as 'wanderers', possibly suggesting population differences involving group movement and/or micro-evolutionary shape change. Again, more data are required. It may well be that the apparently consistent Strøby Egede/Bøgebakken/Skateholm linkage is, at least partially, related to their age. The individuals included cover a total time span between 6690 and 7190 BP for the latter two, and an estimated 6500 BP for Strøby Egede. With no direct radiocarbon dates, the age of the Strøby Egede burial is estimated from associated Ertebølle material recovered during excavation. The only other clearly identifiable group showing similar 'behaviour' in the analyses, and a similar age profile, is the south German dataset, dated between 8170 and 8650 BP. What is the role of the roughly 1600 year difference in average age between these contrasted samples?

Finally, other findings from our analyses extend beyond the tight focus of this paper, centred initially on Strøby Egede, and secondly on the Strøby Egede/Bøgebakken/Skateholm 'group'. We would be remiss for not mentioning the following, though we have no current explanations for the observed patterns. They do, however, provide bases for further work.

- Strøby Egede A (16, female) and Bøgebakken 3 (5, male) tend to act as outliers and cluster together, most clearly in Figure 4. It is tempting to suggest a common geographic origin. That they might come from Germany was a possibility. However, the available German data are not supportive. Poland is a possibility but with no data currently available.
- To the best of our knowledge no clear extension of the model of 'regional clustering demonstrated by Vang Petersen (1984) … based on lithic typology and style' has been published. However, Brinch Petersen (2015, 140–7) has discussed the relationship(s) between Sjælland and Skåne and the 'Movement of newcomers' at Bøgebakken. Evidence for extensive relationships across the intervening Øresund are not present, but the recovery in Sjælland of 'bones, pendants and tools' from Skåne is clear. The full dynamic pattern between the two regions is anything but fully explained but there is linkage between the two areas that needs further study.
- The Strøby Egede A and D individuals do not tend to cluster together, though both fall within the Bøgebakken range. This certainly fits the idea of linkage of eastern Sjælland site groups.
- The Vedbæk-Boldbaner male (18 in Fig. 4) consistently fell outside the Bøgebakken range, though both sites are in the same fjord. Vedbæk-Boldbaner is older by *c.* 900 years based on site means BP and we might suggest change in the local population over this time.
- And, finally, a paradoxical point is that three individuals chosen as geographic outliers consistently failed to act in this fashion: Bleivik from Norway and Bäckaskog and Stora Bjers from central Sweden. In fact, Bleivik and Bäckaskog acted as a pair in both PCA and cluster analysis approaches, within the central core of the overall sample. Without an obvious explanation we see this as a possible random artefact of the database. However, it is also a possible marker for overall biological homogeneity in the late Scandinavian Mesolithic.

## NOTES

[1]We use local Danish and Swedish spellings of geographical terms through the text. For those not familiar with these, the pairings are as follows in the format 'Danish or Swedish=English' (Jylland=Jutland; Sjælland=Zealand; Skåne=Scania).

[2]Note that the 1998 study overlapped other statistical analyses concerned with craniometric variability in the European Mesolithic, though with broader geographic focus. Earlier key papers include Constandse-Westermann (1974), Henke (1989), and Petersen (1997).

[3]Data collected by Trinette Constandse-Westermann (TSCW) in 1987 was preferred where it diverged from that collected by Persson, as TSCW and CM had compared methods while working together between 1977 and 1981 on material from the Swifterbant sites excavated from the Dutch Flevoland Polder (Meiklejohn &

Constandse-Westermann 1978; Constandse-Westermann & Meiklejohn 1979).

[4]Data sources are included in Table 1 and the bibliography. Where the source has not been previously published, we use the following indicators; cm for data collected by C. Meiklejohn, hcp for data collected by H.C. Petersen, and tscw for data collected by T.S. Constandse-Westermann. Collection dates are included where available.

[5]This measures the degree to which the dendrogram or cluster fits the distance between data points seen in the original PCA. A full or perfect fit would produce a value of 1.000.

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## RÉSUMÉ

*Strøby Egede, Vedbæk-Bøgebakken et les relations entre les vestiges ostéologiques du Mésolithique de Scandinavie*, par Jeff Babb, Christopher Meiklejohn, Hans Christian Petersen, et Maureen Babb

Cet article est issu de nouvelles recherches sur les vestiges ostéologiques humains de Strøby Egede, un site situé près des côtes dans l'est du Sjælland. Il a deux objectifs. Le premier est de confirmer la détermination du sexe des individus à partir du travail original mené en 1986. Le second et principal objectif est de réexaminer les observations faites par l'un d'entre nous (CM) à partir d'un travail fait en 1992, et de proposer une nouvelle analyse statistique incluant les données des deux adultes de Strøby Egede. En 1998, nous avions suggéré que l'échantillon de Strøby Egede était plus proche de Skateholm, sur les côtes de Skåne dans le sud de la Suède, que de Vedbæk-Bøgebakken dans le Sjælland, en accord avec les analogies des matériels lithiques notées auparavant par Vang Petersen. Nous revenons sur cette proposition de 1998, en comparant les données de Strøby Egede avec celles provenant du sud de la Scandinavie et de l'Allemagne, et concluons que l'hypothèse de 1998 était, selon toute probabilité, erronée. L'analyse ci-dessous souligne les similarités morphologiques entre les individus de l'est du Sjælland et de Skåne, tout en notant l'existence de cas particuliers.

## ZUSAMMENFASSUNG

*Strøby Egede, Vedbæk-Bøgebakken und die Beziehungen zwischen Skelettmaterial aus dem skandinavischen Mesolithikum*, von Jeff Babb, Christopher Meiklejohn, Hans Christian Petersen, und Maureen Babb

Dieser Artikel ist das Ergebnis neuer Arbeiten an mesolithischem menschlichem Skelettmaterial aus Strøby Egede, einer küstennahen Fundstelle im östlichen Sjælland, mit zwei Schwerpunkten. Der erste bestätigt die



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Geschlechtsbestimmung aus der ursprünglichen Arbeit von 1986. Der zweite und zentrale Schwerpunkt befasst sich mit der Überprüfung von Kommentaren eines von uns (CM), die auf Arbeiten aus dem Jahr 1992 beruhen, sowie mit einer neuen statistischen Analyse, die Daten von zwei Erwachsenen aus Strøby Egede einschließt. 1998 wurde die Vermutung geäußert, dass das Material aus Strøby Egede eher Skateholm an der Küste von Skåne in Südschweden ähnelt als Vedbæk-Bøgebakken auf Sjælland, was zu den von Vang Petersen früher festgestellten Mustern im lithischen Material passt. Im Folgenden gehen wir auf die Überlegungen von 1998 ein und vergleichen die Daten von Strøby Egede mit denen aus Südskandinavien und Deutschland. Wir sind der Meinung, dass der Kommentar von 1998 höchstwahrscheinlich falsch war. Die nachstehende Analyse deutet auf eine allgemeine morphologische Ähnlichkeit zwischen den Individuen in Ost-Sjælland und Skåne hin, wobei jedoch offensichtliche Ausreißer festzustellen sind.

## RESUMEN

*Strøby Egede, Vedbæk-Bøgebakken y las relaciones entre los materiales esqueléticos del Mesolítico escandinavo*, por Jeff Babb, Christopher Meiklejohn, Hans Christian Petersen, y Maureen Babb

Este artículo deriva de nuevos trabajos realizados a partir de los restos humanos mesolíticos de Strøby Egede, un yacimiento costero en el este de Sjælland, con dos enfoques. El primero confirma las identificaciones del sexo llevadas a cabo en los trabajos originales de 1986. El segundo, y el foco principal de este artículo, re-examina los comentarios realizados por uno de nosotros (CM) a partir de los trabajos de 1992, e incluye los nuevos análisis estadísticos a partir de los datos de dos individuos adultos de Strøby Egede. En 1998 se sugirió que la muestra de Strøby Egede se asemejaba más a Skateholm, en la costa de Skåne en el sur de Suecia, que a Vedbæk-Bøgebakken en Sjælland, en función de los patrones de la industria lítica observados anteriormente por Vang Petersen. Procedimos a una revisión de esta sugerencia en 1998, comparando los datos de Strøby Egede con aquéllos disponibles para el sur de Escandinavia y Alemania y sugiriendo que el comentario de 1998 era, con toda probabilidad, incorrecto. El análisis que se presenta sugiere una similitud morfológica entre los individuos del este de Sjælland y Skåne, a la vez que se señala la inexistencia de aparentes valores atípicos.