Refining the time span between the early Holocene Askja-S and Hässeldalen tephras through differential dating based on varve counting from Lake Czechowskie (N Poland)

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Objectives & Study site

- **Annually laminated (varved)** sediment records provide a tool for **differential dating** (precise determination of the time between tephra layers) (Lane et al., 2015)
- **Hässeldalen** and **Askja-S** tephras are regarded as key isochrones for synchronizing early Holocene sediment archives in N and W Europe
- Stratigraphic importance due to their occurence before (Hässeldalen) and after (Askja-S) the **Preboreal Oscillation (PBO)** (Wohlfarth et al., 2006)
- age estimates for both tephras rely on different chronological modelling techniques resulting in **rather large uncertainties** (**Tab. 1**)
- Identification of coexisting **Hässeldalen** and **Askja-S** tephras for the **first time** in varved sediments of Lake Czechowskie (N Poland) (**Figs. 1 & 2**)
- This study aims to:
  - (i) Determine the time span between both tephras based on varve counting
  - (ii) Compare time span with published absolute ages
  - (iii) Discuss a possible PBO impact on Lake Czechowskie

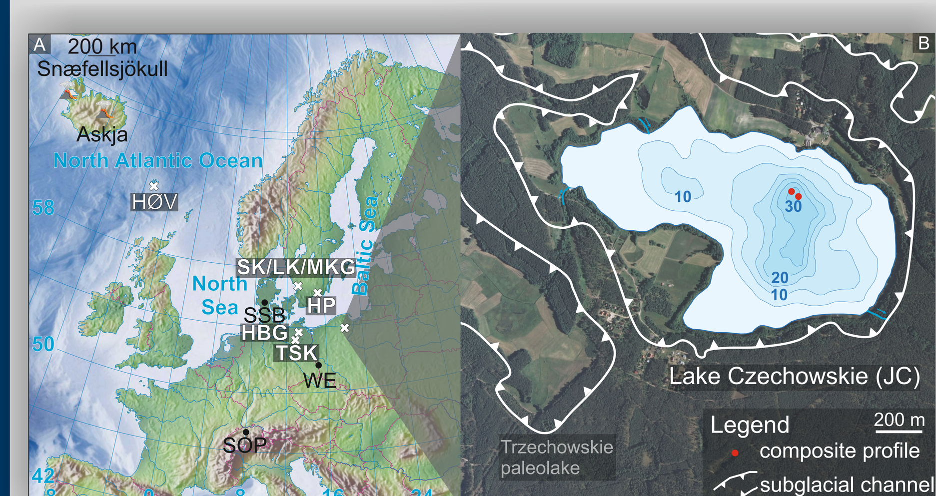

Figure 1. *(A) Location of published records with coexisting findings (white crosses) or single occurrences (black dots) of the Hässeldalen and the Askja-S tephras: Høvdarhegi Bog (HØV) on the Faroe Islands (Lind and Wastegård, 2011), Storå Kräckebosjön (SK), Lilla Kräckebosjön (LK) and Mulakullegöl (MKG) in SW Sweden (Lilja et al., 2013), Hässeldala Port (HP) in SE Sweden (Davies et al., 2003), Store Slotseng basin (SSB) in SW Denmark (Larsen and Noe-Nygaard, 2014), Endinger Bruch/Hoher Birkengraben (HBG) and Lake Tiefer See (TSK) in NE Germany (Lane et al., 2012b; Wulf et al., 2016), Wegliny (Housley et al., 2013) (WE) in SW Poland and Lake Soppensee (SOP) in Switzerland (Lane et al., 2011). Grey shading displays the position of Lake Czechowskie (Ott et al., 2016; Wulf et al., 2016). The overview map also shows the location of the Askja and the Snæfellsjökull volcanoes on Iceland. (B) Aerial image of Lake Czechowskie with position of sediment cores (red dots), a simplified lake bathymetry and catchment morphology (modified after Błaszkiewicz 2005, 2015).*

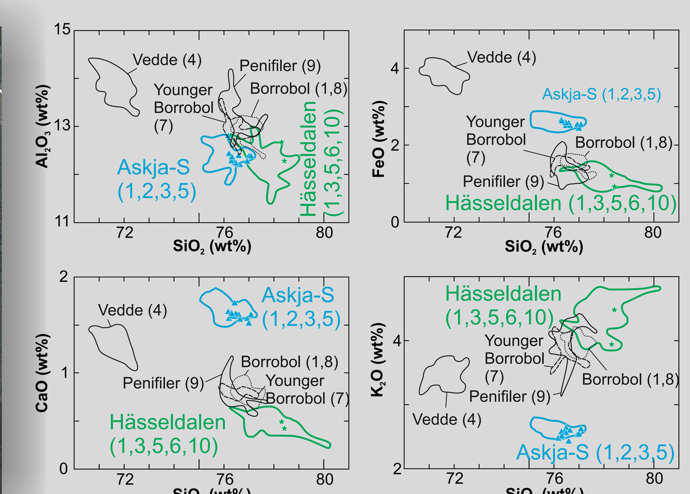

Figure 2: *Bivariate plots of selected major elements of single glass chemical composition (normalized, water-free data) of the Hässeldalen (green stars) and Askja-S (blue triangles) cryptotephras in JC. These data are compared with published EPMA glass data of rhyolitic Lateglacial and Early Holocene Icelandic tephras (envelopes: [1]Davies et al., 2003; [2]Lane et al., 2011; [3]Lind and Wastegård, 2011; [4]Lane et al., 2012a,b; [5]Lane et al., 2011; [6]Housley et al., 2013; [7]Ranner et al., 2005; [8]Turney et al., 1997; [9]Pyne-O'Donnell et al., 2008 and [10]Lilja et al., 2013)*

Table 1: *Overview of published ages for the Hässeldalen and Askja-S tephras. All informatio has been taken from the original references listed. The listed age ranges are according to the calibration dataset valid at the time of publication.*

Lab code/ sample name	Sediment record	Modelled age [cal a BP, 95.4%]	Calibration dataset	Calibration/modelling procedure	Remarks	Reference
Askja-S						
	Hässeldala port	11 070-10 750	IntCal04	WMD in Bpeat	Model A	Wohlfarth et al. (2006)
	Hässeldala port	11 050-10 570	IntCal04	Sectioned, WMD in Bpeat	Model B	Wohlfarth et al. (2006)
Sop_T5.19	Lake Soppensee	10 991-10 702	IntCal09	OxCal v4.1; P_Sequence	Lithostratigraphic boundaries	Lane et al. (2011)
Sop_T5.19	Lake Soppensee	11 005-10 745	IntCal13	OxCal v4.2; P_Sequence	Model 1, strati-graphic boundaries	Bronk Ramsey et al. (2014)
Sop_T5.19	Lake Soppensee	10 956-10 726	IntCal13	OxCal v4.2; P_Sequence	Model 2, variable sed. rate	Bronk Ramsey et al. (2014)
	Faroe Islands	10 500-10 350	IntCal09	OxCal v4.1		Lind and Wastegård (2011)
Hässeldalen						
	Hässeldala port	11 565-11 299	IntCal04	WMD in Bpeat	Model A	Wohlfarth et al. (2006)
	Hässeldala port	11 543-11 232	IntCal04	Sectioned, WMD in Bpeat	Model B	Wohlfarth et al. (2006)
	Hässeldala port	11 596-11 164	IntCal04	Chronologial ordering assumed, WMD in Bcal	Model C	Wohlfarth et al. (2006)
	Faroe Islands	11 360-11 300	IntCal09	OxCal v4.1		Lind and Wastegård (2011)

Sediments & Differential dating

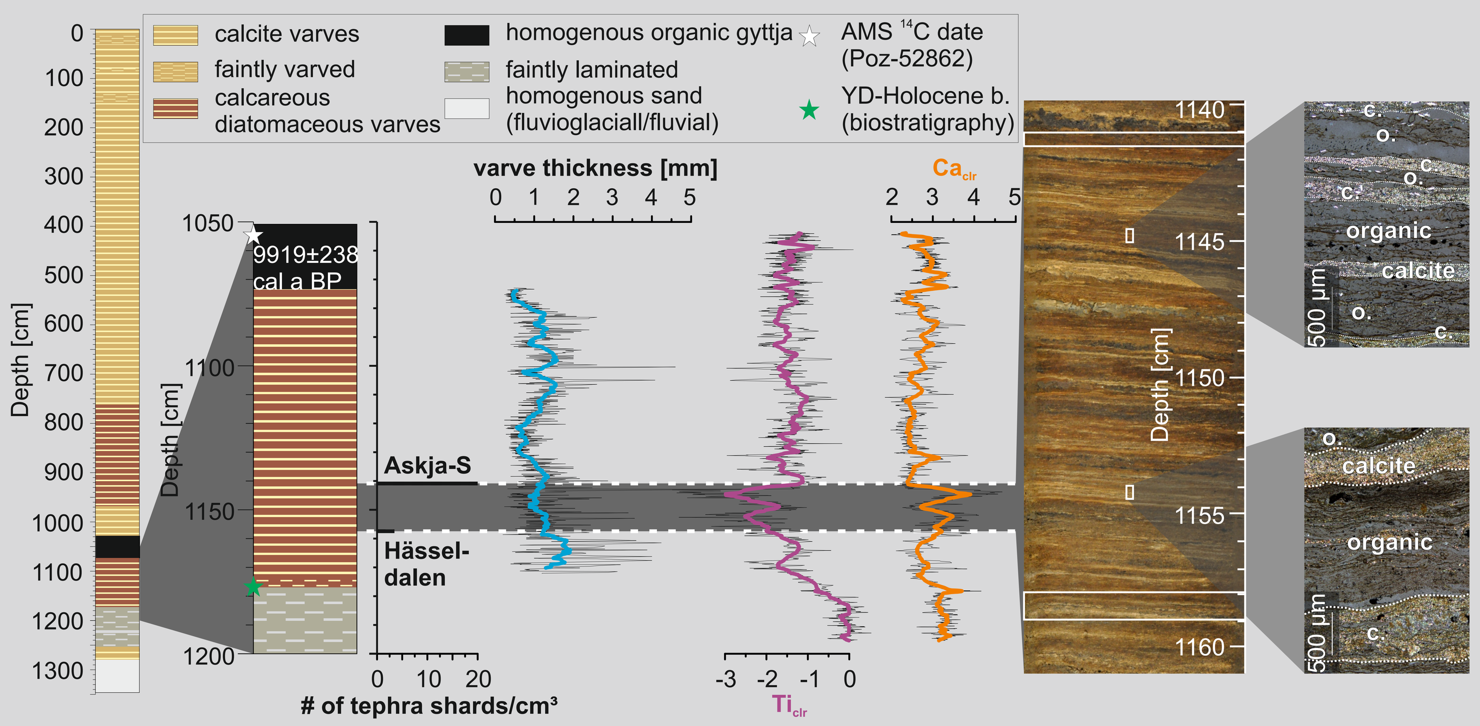

Figure 3. *Lithological composite profile of Lake Czechowskie sediment record (JC-M2015) with detailed study interval (1050–1200cm). White dashed lines indicate the position of the Askja-S (1141.25cm) and the Hässeldalen (1158.5cm) cryptotephras together with their concentration (number of glass shards cm[3] wet sediment). The green and grey stars indicate the biostratigraphical Younger Dryas–Preboreal boundary (1176– 1177cm) and the closest [14]C AMS-dated organic sample (1054 cm), both indicating an early Holocene age for the identified tephras. Varve thickness (blue), Ti_{clr} (purple) and Ca_{clr} (orange) records are plotted together with 30-year running averages (thick lines). The vertical grey box indicates the interval bracket by the Hässeldalen and Askja-S cryptotephras. The exact positions of the cryptotephra occurrences within the varved sediment interval are indicated in the core photograph (white boxes). Microphotographs (10x magnification, semi-polarized light) of thin sections show varve structures in more detail.*

- **Differential dating** based on varve counting reveal a time span of **152 +11/-8 varve years** between both tephras (**Fig. 3**)
- **In agreement** within the uncertainties from radiocarbon based age models from non-varved **Hässeldala port** (94-1024 years) but **shorter** than assumed by the non-varved **Faroe Islands** record (800-1010 years) (**Fig. 4**)
- **discrepancy of Askja-S** age range from Lake Soppensee due to the **reduced uncertainty ranges** in recent age models
- considering a **single [14]C date** instead of modelled ages would **reconcile the JC results** within larger uncertainties

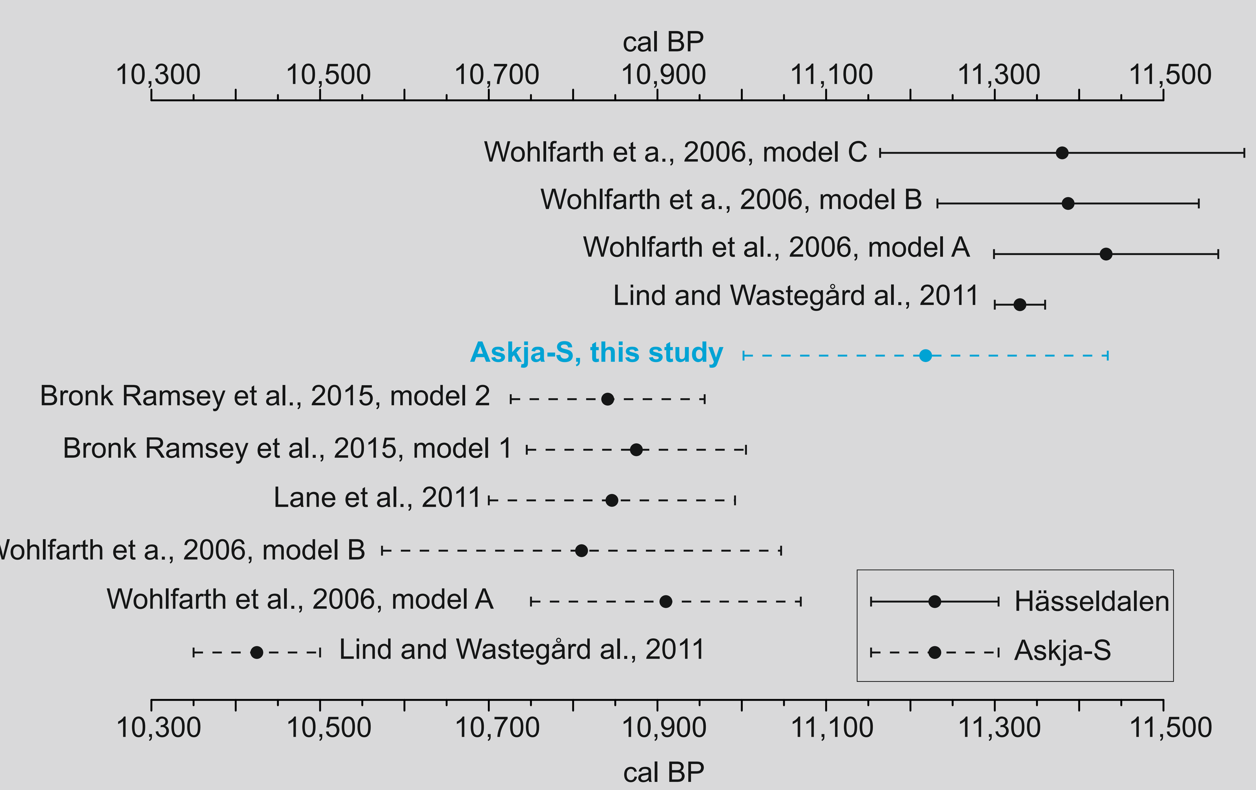

Figure 4. *Overview of published age ranges of (i) Hässeldalen (solid line) and (ii) Askja-S (dashed line) tephras. The blue line indicates the age of the Askja-S tephra (11 454–11 002 cal a BP) if (i) accepting the radiocarbon-dated Hässeldalen Tephra (11 380±216 cal a BP) as a chronological anchor point and (ii) applying the varve-based differential counting-derived time span between the two tephra horizons.*

Preboreal Oscillation (PBO)

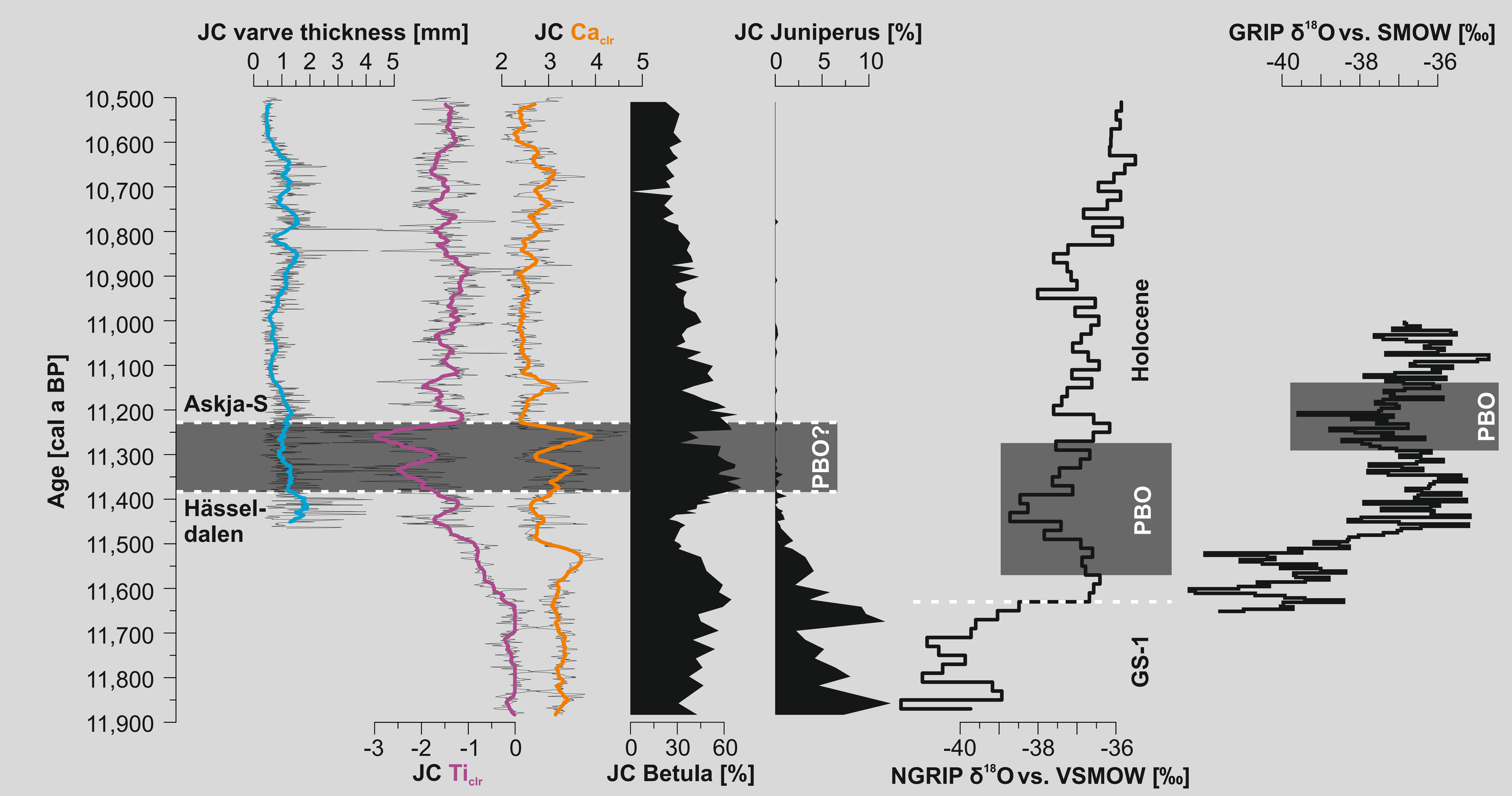

Figure 5. *Varve thickness, Ti_{clr} and Ca_{clr} records for JC are plotted as annual data and as 30-year running means (thick lines). JC pollen data for birch (Betula) and juniper (Juniperus) are plotted on 10-yr average increments. The stratigraphic position of the two tephras is indicated with the white dashed line. The grey bar highlights the approximate position of the PBO. To the right: the PBO as defined in the NGRIP $\delta^{18}O$ data shown on the GICC05 chronology with the PBO (dark grey bar) and the so-called 11.4- ka event (white dashed lines) (Rasmussen et al., 2007, 2014; Kobashi et al., 2008) and in the GRIP $\delta^{18}O$ data (dark grey bar) (Björck et al., 1996). The grey dashed line indicates the transition from GS-1 (Greenland Interstadial-1) to the Holocene in NGRIP (Rasmussen et al., 2014).*

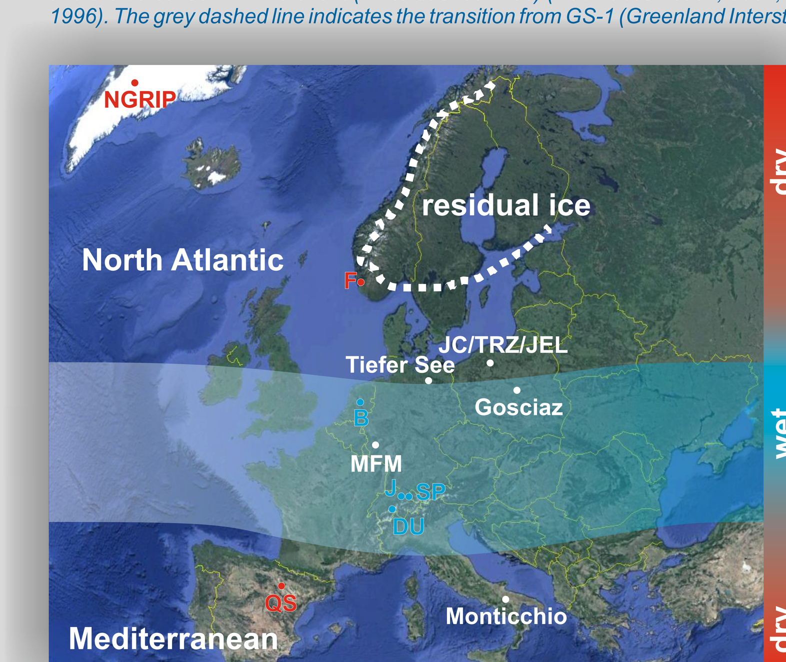

Figure 6. *Paleoclimate records displaying hydrological oscillations (red=dry; blue=wet) during the Early Holocene (modified from Magny et al., 2007). Blue band shows the tentative position of the southern- and northernmost extent of wet conditions associated with the PBO. Varved lake records (white dots) display potential for future transect studies along climatic gradients for detailed paleoclimate investigations.*

- indication of **dry phase** bracketed by the Hässeldalen and Askja-S tephras (**Betula decline, lower Ti input**) (**Fig. 5**)
- duration (**60-170 varve years**: 60 v. yrs Betula decline; 170 v. yrs Ti decrease)
- correlation to PBO only **tentative** due to:
  - (i) **weak proxy response** in JC
  - (ii) **unclear regional signals** (dry vs. wet phase; terrestrial vs. „ice core" PBO)
  - (iii) lacking data whether PBO is **only a single cold oscillation (?)** (**Fig. 6**)

Poster @ a glance - 1 min summary

Objectives

- refining the duration between Hässeldalen & Askja-S tephras
- impacts/changes during PBO in N Poland

Data

- 152 varve years between both tephras
- indication of dry phase bracketed by both tephras (PBO?)

Outlook

- re-evaluation of published ages is needed
- tephras as tie points for transect studies (e.g. climatic gradients)

Author information

Corresponding references

Ott et al. (2016). Constraining the time span between the Early Holocene Hässeldalen and Askja-S Tephras through varve counting in the Lake Czechowskie sediment record, Poland. JQS. Online first

Wulf et al. (2016). Lateglacial and Holocene tephrostratigraphy of varved sediment records from Northern central European lowlands - first results from Lakes Tiefer See (NE Germany) and Czechowskie (N Poland). QSR 132: 1-14

Additional references

Björck S, et al. (1996). Science 274(5290): 1155–60; **Błaszkiewicz M**, (2005). IGiPZ PAN; **Błaszkiewicz M**, et al. (2015). QSR 109: 13–27; **Blockley SPE**, et al. (2014). QSR 106: 88–100; **Davies SM**, et al. (2003). QR 59(3): 345–352; **Housley RA**, et al. (2013). Quaternary Science Journal 77: 4–18; **Kobashi T**, et al. (2008). EPSL 268(3-4): 397–407; **Lane CS**, et al. (2011). QI 246(1-2): 145–156; **Lane CS**, et al. (2015). QSR 122: 192–206; **Lane CS**, et al. (2012). JQS 27(2): 141–149; **Larsen JJ** and **Noe-Nygaard N** (2014). Boreas 43: 349–361; **Lilja C**, et al. (2013). Boreas 42(3): 544–554; **Lind EM** and **Wastegård S** (2011). QI 246(1-2): 157–167; **Magny M**, et al. (2007). QSR 26: 1951-1964; **Pyne-O'Donnell SDF**, et al. (2008). QSR 27(1-2): 72–84; **Ranner PH**, et al. (2005). JQS 20(3): 201–208; **Rasmussen SO**, et al. (2014). QSR 106: 14-28; **Rasmussen SO**, et al. (2007). QSR 26(15-16): 1907–1914; **Turney CSM**, et al. (1997). JQS 12(6): 525–531; **Wohlfarth B**, et al. (2006). JQS 21(4): 321–334.

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