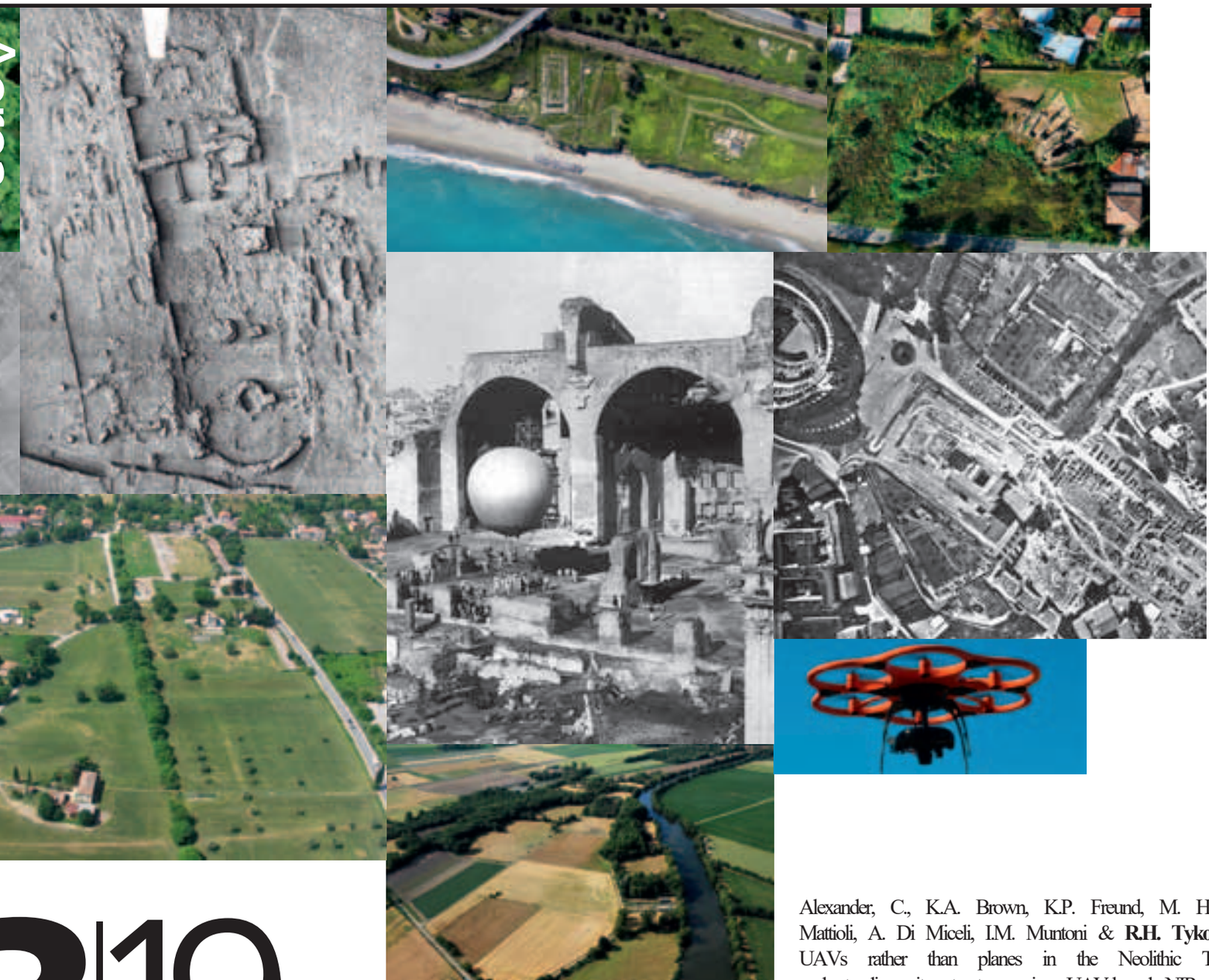
Studi di Aerotopografia Archeologica

Archeologia Aerea



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13 | 19

a cura di
Veronica Ferrari

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"Archeologia Aerea. Studi di Aerotopografia Archeologica" è una Rivista Internazionale fondata nel 2004 da Giuseppe Ceraudo e Fabio Piccarreta.
Dotata di *referees* anonimi (*peer-reviewed*), raccoglie studi e ricerche di archeologia basati sull'ampio utilizzo di fotografie aeree, immagini satellitari e dati telerilevati in genere.
L'opera – unica nel suo genere in Italia – segue la disciplina sin dai suoi esordi e, passando attraverso contributi di metodologia e applicazioni di fotointerpretazione archeologica e fotogrammetria finalizzata, giunge sino alle modernissime applicazioni specialistiche legate alle nuove tecnologie di *remote sensing* e fotointerpretazione satellitare.
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SOMMARIO

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UAVs rather than planes in the Neolithic Tavoliere
Understanding site structure using UAV-based NIR imaging and photogrammetric mapping, magnetometry and field survey

Abstract
This paper presents the results of field walking, magnetometer survey and UAV-based near infrared (NIR) photogrammetry at the Tavoliere Neolithic site designated J155/FG003663/ Posta Barone Grella I southwest of Cerignola (FG) in Puglia. These techniques were utilised as a means of locating areas for future excavation: the methodology presented here in turn provides a framework for future archaeologists interested in understanding the nature of subsurface site structures prior to excavation. Of particular note is the fact that the NIR photography picked up boundary ditches even though the crops in the field had already been harvested. Agreement between magnetometer survey and UAV-based imaging was also strong.

Introduction

The Neolithic Tavoliere (ca. 6000-4000 BC) saw some of the densest Neolithic settlement ever recorded, with more than 800 settlements (fig. 1) across an area of about 50 x 60 km[1]. Most of these settlements have been discovered on the basis of aerial photographs, beginning just after the Second World War (fig. 2) with the work of Bradford[2] on Allied reconnaissance images, continuing with Jones[3] and then Brown[4]. Settlements typically consist of a series of C-shaped ditches, 1.0-1.5 m in depth cut through the *crusta* carbonate layer and, often, one or more boundary ditches of 2-3 m in width and similar depth. At the time of writing, analysis of aerial photographs continues to yield new sites.

1 - Position of Tavoliere (inset) and distribution of Neolithic sites based on Carta dei Beni Culturali.

Gallo *et al.* (2009) first integrated modern oblique aerial photography (using a fixed wing aircraft at 400-600 m altitude) with the results of magnetometer survey in a GIS framework while considering the Neolithic Tavoliere site of Masseria Anglisano (noted as site J245 by Jones[5], west of Foggia. The current paper builds on this work at the more southerly site (fig. 3) of Posta Barone Grella I (J155 noted by Jones[6] or FG003663 in the Puglia *Carta dei Beni Culturali*), incorporating the use of near infrared (NIR) imaging rather than visible light, using an unmanned aerial vehicle (UAV) rather than a crewed aircraft and adding the results of field survey.

Research project

Since 2013, current authors Alexander, Brown and Tykot (and, since 2014, Freund) have been collaborating on a research project under the supervision of current author Muntoni of the *Soprintendenza Archeologia della Puglia*. The project has focussed on field walking Neolithic sites across the Tavoliere to collect samples of ceramics and lithics (especially obsidian) post-harvest. Every sample has been individually georeferenced with an EGNOS (European Geostationary Navigation Overlay Service)-capable handheld GPS (Global Positioning System) unit. To date, more than 1,220 samples have been collected and analysed with a portable X-ray fluorescence (pXRF) spectrometer to determine their trace element composition. In addition, the project has collected more than 70 samples of modern riverine clays that have also been analysed with the spectrometer. The aim has been to identify the likely clay sources used in the ceramics found at each site and thereby to reconstruct patterns of exchange and mobility: the results of this work will be the subject of future publications.

In 2015, the team leaders decided to supplement field walking and clay sample gathering with geophysical and UAV-based photogrammetry analyses of sites deemed particularly likely to be well-preserved and of significant potential for future excavation. Several sites were investigated, but in this paper we focus on Posta Barone Grella I (J155/FG003663) as it was the only site cho-

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2 - World War 2 aerial photograph showing Passo di Corvo (site J198).

sen on the basis of our own field walking. In particular, field survey early in the 2015 season yielded large quantities of Neolithic sherds significantly larger than those found at most sites over the previous two years. The Tavoliere is an area of intensive agriculture and, since World War Two, many sites have been destroyed by deep ploughing. The larger pottery fragments found at Posta Barone Grella I suggest that plough damage may be less at this site. A conversation with the landowner's foreman also suggested relatively shallow ploughing to date. We thus decided to investigate this site along with others that had been suggested by the *Soprintendenza Archeologia della Puglia*.

This paper in turn presents the results of a combination of archaeological/remote sensing techniques applied to the Posta Barone Grella I site. This methodology is of particular interest for those archaeologists interested in understanding the nature of subsurface site structures prior to excavation.

Methodology

Expertise in UAV-based imaging was brought to the team by *Dipl. Ing.* Manuel Hofer of the Graz University of Technology,

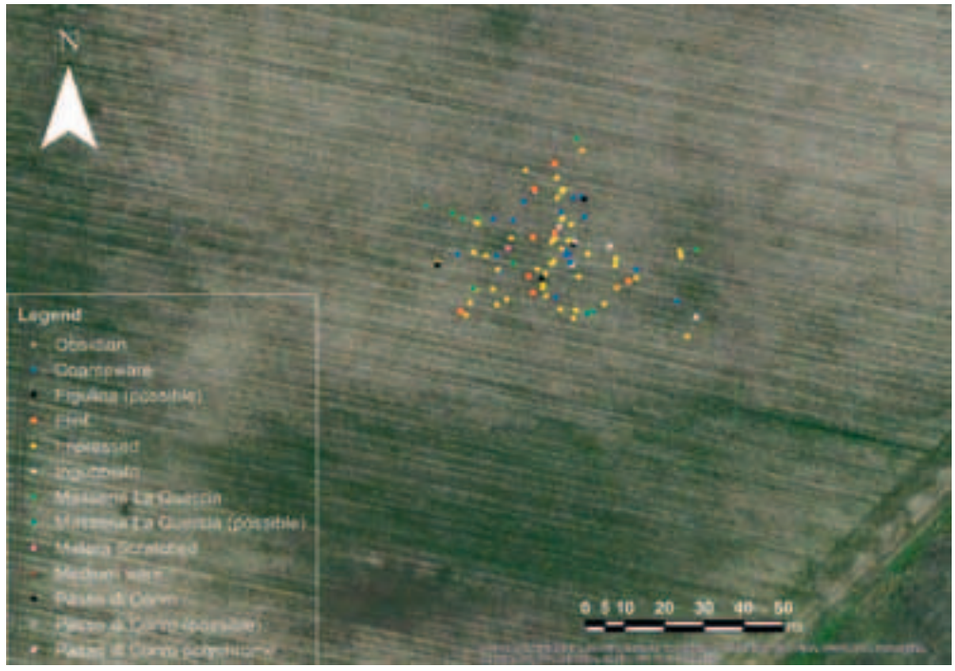
Austria. Hofer has considerable experience in UAV-based 3D imaging, including some with prehistoric European rock-art and its landscape (3d-pitoti.eu). Our decision to use NIR rather than visible light imaging was based on the experience of Verhoeven[7] with digital NIR in Italy.

The UAV employed was a fixed wing SenseFly eBee (www.sense-fly.com). The eBee has a 96 cm wingspan and weighs 0.69 kg. The eBee can fly for up to 50 minutes and can handle winds of up to 45 km/hr. The NIR camera has a 12 MP sensor and maximal ground resolution is 1.5 cm/pixel.

At each site, the UAV was flown at 3 different altitudes (80 m, 100 m and 120 m) and the resulting photographs were combined later. Three dimensional landscape reproduction is achieved through standard Structure from Motion techniques, in this case using the software first introduced by Irschara *et al*[8]. A sparse mesh can be generated in about an hour and a dense point cloud and textured mesh each take a few hours to generate. Georeferencing of the mesh was achieved using data from the UAV's on-board GPS and algorithms developed by Rumpler *et al*[9].

Geophysical prospection skills were contributed by ArcheoRes (www.archeores.com), an affiliate of the *Università di Perugia*. The ArcheoRes team used a Geometrics G858 instrument for magnetometer survey (the use of electrical resistance tomogra-

3 - Location of the site Posta Barone Grella I.



4 - Finds from field walking survey of Posta Barone Grella I.

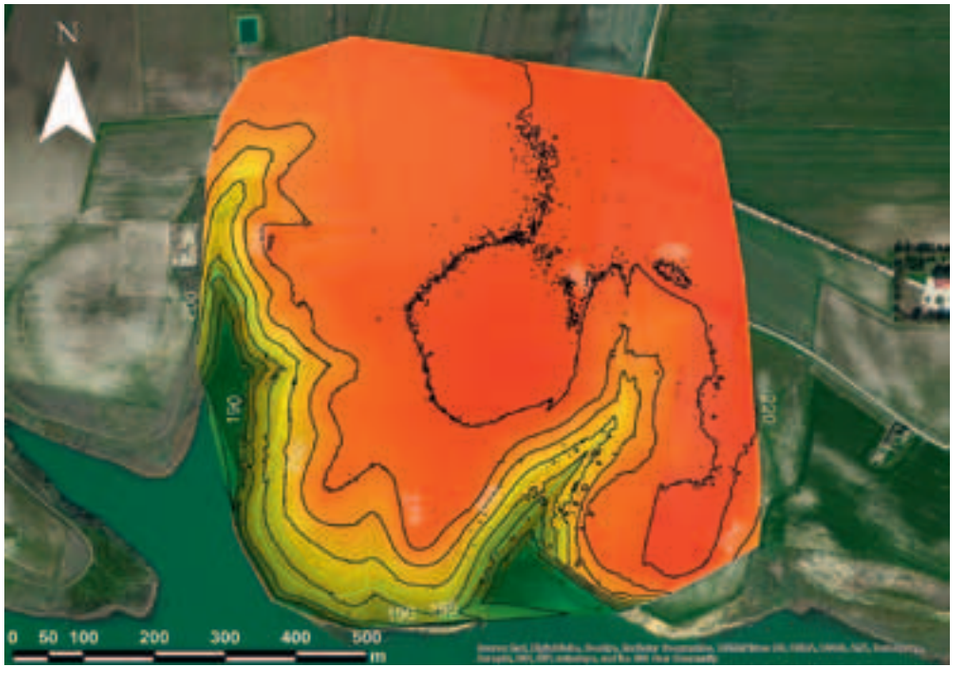
phy was tested at another site but was not used at Posta Barone Grella I). A 20 x 160 m transect was walked, the transect being aligned to include both an apparently circular pattern of finds from the field walking and the boundary ditches as identified in aerial photographs. Figure 4 shows the find spots from our team's field walking of the site: note the apparently C-shaped distribution of Impressed Wares (yellow dots) to the lower centre right. Our magnetometer transect was designed to intersect this in case it represented one of the C-shaped ditches that typically surround buildings within the outer enclosure ditches of the Tavoliere Neolithic sites. ArcheoRes georeferenced their data with a differential GPS (DGPS) system.

All data – field walking find spots, UAV-based NIR photogrammetry and magnetometry results – were linked (via UTM 33N/WGS84 coordinates) in an ArcGIS 10.2 database.

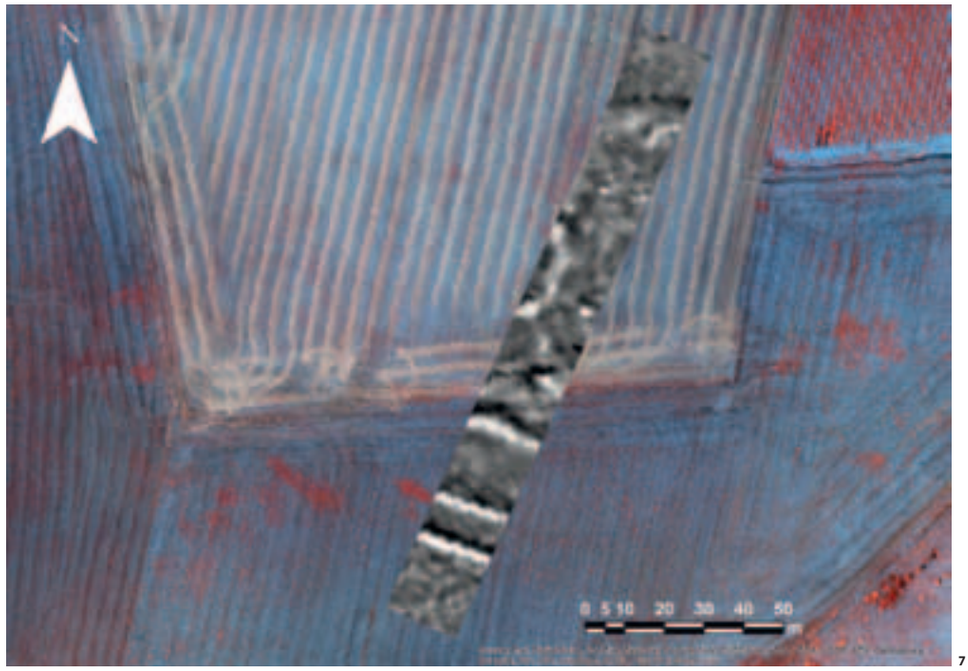
Results

The magnetometry survey showed the boundary ditches, which were also visible in the aerial photography (ArcGIS basemap), very well and also identified a variety of internal ditches (fig. 5). The NIR imagery from the UAV produced a high-resolution dig-

5 - Results of magnetometer survey.

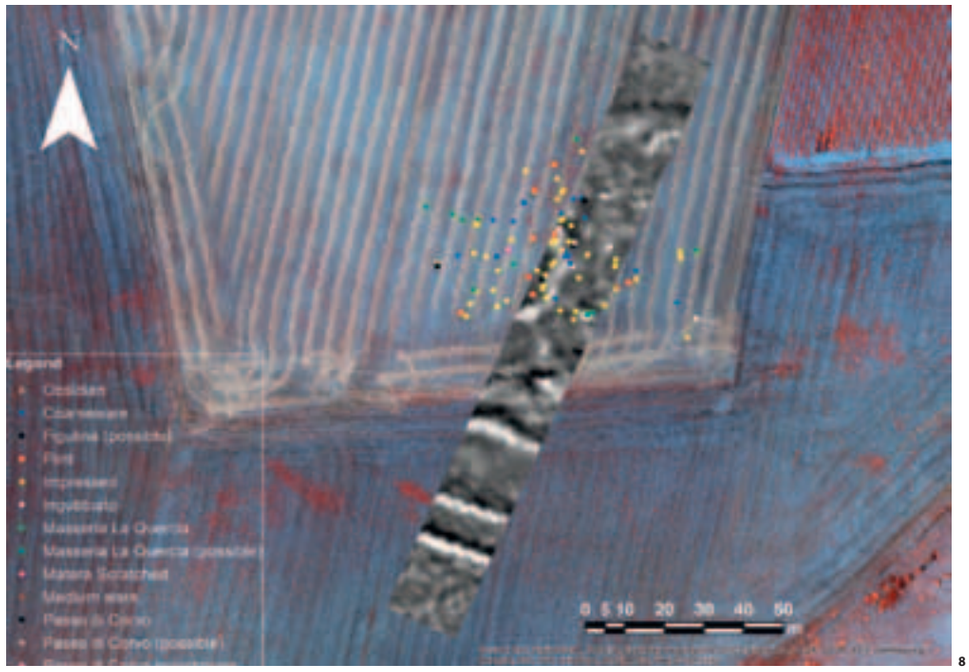


6 - Digital Surface Model (DSM) from UAV photogrammetry with 5 m contours.



7 - NIR photogrammetry and magnetometer results.

7



8 - Results of field survey, magnetometer survey and NIR UAV photogrammetry.

8

ital surface model (DSM) (fig. 6). Of particular interest is the apparent visibility of boundary ditch segments (fig. 7): usually one does not expect NIR imagery to show underlying features after the harvest as feature identification relies on differential surface temperature. In this case, perhaps the relatively short time elapsed since harvest (one to two weeks based on conversations with the landowner's foreman) was responsible for the positive result.
The coincidence of the NIR-detected ditches and those detected by magnetometer is good, with about a 4 m offset that presumably results from the difference between the DGPS readings used for the magnetometer survey and the regular GPS readings used for the NIR imagery.

Discussion

We have shown that both digital NIR imagery from a UAV and magnetometer survey can detect the ditches of Tavoliere Neolithic settlements. In this, we have built on the results of Gallo et al.'s earlier research[10]. We have also shown that NIR can be effective even post-harvest. Finally, we have gone even further in integrating the results of field survey with the remote sensing technologies (fig. 8).
But what of that suggestively circular arrangement of Impressed Ware finds (fig. 4)? The magnetometer survey did identify a C-ditch nearby, but it is about 15 m to the west of the apparent cir-

cular group on Impressed Ware finds. As EGNOS should provide a horizontal accuracy of 3 m or so we are, reluctantly, forced to conclude that the distribution of Impressed Ware finds is, in fact, merely random.

However, the strong results from both geophysical survey and UAV-based NIR imaging, along with the large sizes of the ceramic fragments recovered from the surface, suggest that this site may well be relatively undamaged and could be rewarding for a modern scientific excavation.

There is, though, one caveat: as Brown has noted[11], well-defined boundary ditches do not necessarily imply well-preserved internal structures such as huts etc. Our magnetometer transect did not intersect the centres of any C-ditches and so we do not currently know whether the Neolithic surface within C-ditches is well preserved. Further geophysical survey should be undertaken prior to excavation.

In this paper we have presented the results obtained from a combination of archaeological techniques applied to the Posta Barone Grella I site. We integrated a number of remote sensing techniques alongside more tradition archaeological methods as a means of locating subsurface site structures. Such a methodology can be applied not only to the Neolithic Tavoliere, but also to other archaeological contexts.

Acknowledgements

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ENDNOTES

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[1] BRADFORD, WILLIAMS-HUNT 1946; BRADFORD 1949; BRADFORD 1950; BROWN 1991; BROWN 2004; JONES 1987; WHITEHOUSE 2013.
[2] BRADFORD, WILLIAMS-HUNT 1946, BRADFORD 1949.
[3] JONES 1987.
[4] BROWN 2004.
[5] JONES 1987.
[6] JONES 1987.
[7] VERHOEVEN 2012.
[8] IRSCHARA *et al* 2007.
[9] RUMPLER *et al.* 2016.
[10] GALLO *et al.* 2009.
[11] BROWN 1998.

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