New Radiocarbon Dates from Prehistoric Non Nok Tha, Don Kok Pho and Don Pa Daeng, Upper Nam Phong Watershed, Khon Kaen Province, Northeast Thailand

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Abstract

Between 1963-1964 American and Thai archaeologists, in anticipation of dam and infrastructure development, conducted surveys and salvage excavations in northeast Thailand. Of the archaeological sites identified during their work, three, located along the Nam (River) Phong in Phu Wiang District, Khon Kaen Province proved especially significant. These mound sites, Don Kok Pho (NP6), Non Nok Tha (NP7) and Don Pa Daeng (NP8), were covered in fragments of ceramics, metals, pipes, mollusks and animal bone. Test excavations occurred at all three in 1965, but only Non Nok Tha received systematic excavations in 1966 and 1968. While these excavations at Non Nok Tha were dated using radiocarbon and thermoluminescence techniques, the 1965 test excavations at Non Nok Tha remain undated, as do the excavations at Don Kok Pho and Don Pa Daeng. Here, we report the discovery of two unpublished radiocarbon ages for test excavations at Non Nok Tha and Don Kok Pho, analyzed at the Gakushuin Laboratory, Japan, and six new radiocarbon determinations obtained from additional test excavation samples at these three sites analyzed at the University of Georgia Center for Applied Isotope Studies, Athens, Georgia, USA. Our results from Non Nok Tha align with the previously established chronology for this site. Dates from Don Kok Pho and Don Pa Daeng suggest that these sites are either contemporaneous with or younger than Non Nok Tha. All three sites match the regional Upper Nam Phong Watershed regional chronological sequence.

Keywords

Radiocarbon; Thermoluminescence; Nam Phong; Khon Kaen Province; Thailand; Prehistory

1.0 Introduction

A series of archaeological surveys and excavations within northeast Thailand during the 1960s provided the first insights into patterns of prehistoric human activity in this region, especially in the Upper Nam (River) Phong watershed of the Khorat Plateau. Several areas within this region were immediately recognized for their archaeological potential after a 'salvage' archaeological project designed to identify sites impacted by dam development recorded a series of mound sites (among others) between 1963-1964 (Solheim II 1964; Solheim and Gorman 1966). Ultimately, this 1963-1964 survey identified nine habitation and/or cemetery mound sites along the Upper Nam Phong (NP), and four were test excavated: NP2 (unknown local name), NP6 (Don Kok Pho), NP7 (Non Nok Tha) and NP8 (Don Pa Daeng). Test excavations recovered whole ceramic vessels, bronze and iron metal artifacts, animal bone and shell, worked stone, beads, remnants of architecture, inhumations, cremations and much more (Bayard and Solheim 2009a; Green 1965a; 1965b; 1965c; Solheim and Gorman 1966). These discoveries led to the now iconic 1966 and 1968 excavations at Non Nok Tha – a site that eventually figured heavily in debates surrounding the early use of radiocarbon dating and interpretations, the introduction of plant and animal domesticates, and the emergence of metallurgy within Mainland Southeast Asia (Bayard 1970; 1971a; 1971b; 1972; Bayard and Solheim 2009a; 2009b; Solheim 1968). These early 1960s projects in the Upper Nam Phong spurred additional, important archaeological research projects at nearby and associated sites during the 1970s-1980s. Excavations at Non Nong Chik (Buchan 1973), Don Klang (Schauffler 1976), Non Chai (Charoenwongsa and Bayard 1983; Bayard et al. 1982-1983) and Non Pa Kluay (Wilen 1987), among others (e.g., Non Khaw Wong [Penny 1982] and Non Praw [Buranrak 1994 in Higham 2002]), resulted in a cultural-chronological record spanning over the past 2,000 years, with similar inhumation/cremation styles, ceramic types, faunal remains and metal items discovered between sites (Figure 1). However, while several sites within the Upper Nam Phong have published excavation and radiocarbon or thermoluminescence chronologies, several do not. Here, we establish the chronologies for two sites, Don Kok Pho and Don Pa Daeng, based on their 1965 test excavation sequences, and we reexamine the chronology of the 1965 test excavations at Non Nok Tha. Our archival research

identified two unpublished radiocarbon determinations for Don Kok Pho and Non Nok Tha, and we obtained a total of six new radiocarbon determinations from these two sites and Don Pa Daeng.

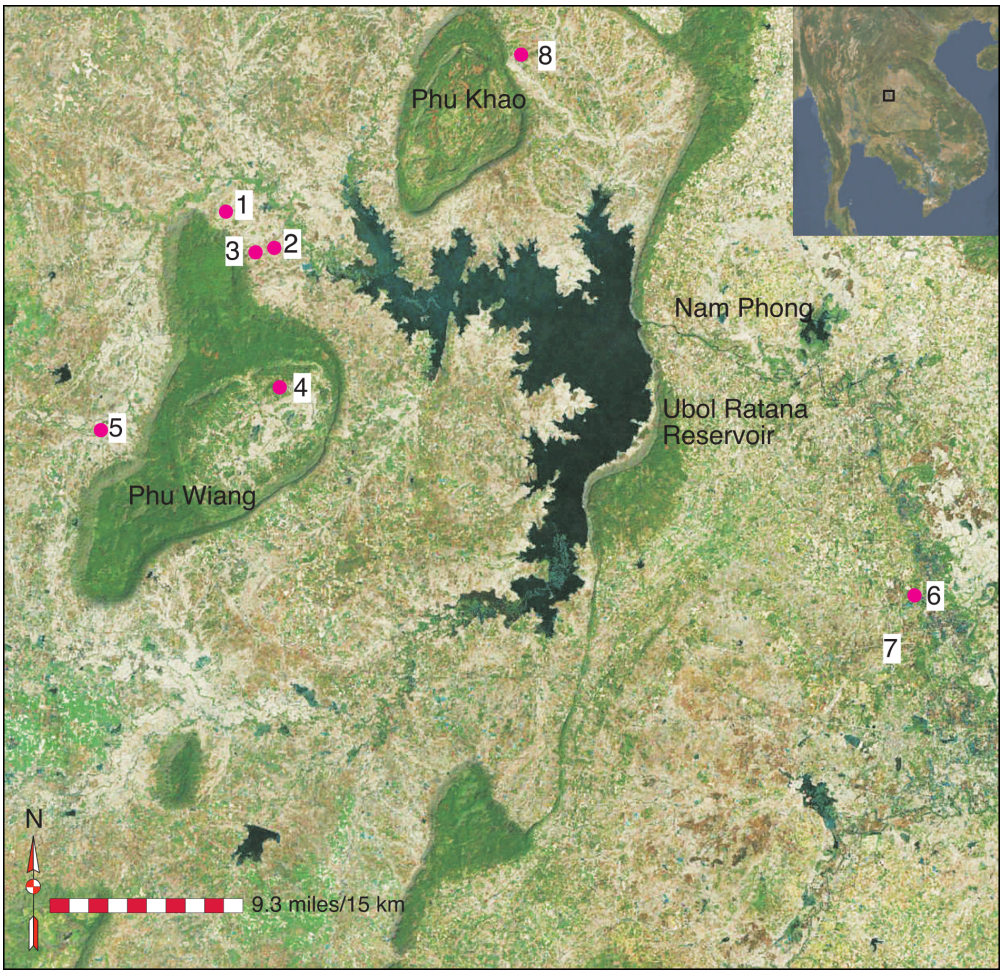

Figure 1. Map of sites discussed in text within the Upper Nam Phong Watershed (see discussions in White and Hamilton 2019), Phu Wiang District, Khon Kaen Province, Thailand. 1) Don Pa Daeng, 2) Don Kok Pho, 3) Non Nok Tha, 4) Non Nong Chik, 5) Non Pa Kluay, 6) Non Chai, 7) the city of Khon Kaen, 8) Don Klang. Inset map shows location within northeast Thailand. The exact location of Non Nok Tha was published as (102° 18′ 17″ E, 16° 47′ 57″ N; Bayard 1970). Base-map courtesy of Dr. Charles Higham, University of Otago.

2.0 Site Backgrounds

2.1 Don Kok Pho (NP6)

Translated as “Base-of-the-Bo-Tree-Upland”, this mound site was identified through survey by Chester F. Gorman on May 3, 1964 (Bayard 1971a; Bayard and Solheim II 2009a; Gorman 1963-1964; see Figure 1) and was excavated by Ernestene Green and Verapong Pengprecha between January 8-17, 1965 (Green 1965a)[1]. The surface artifacts at NP6 consisted of mollusk shell, clay pipe fragments, bronze fragments, a broken tektite, a spindle whorl, ground stone and a large number of ceramic sherds (Bayard and Solheim II 2009a; Solheim II and Gorman 1966). Given that a portion of the mound was cultivated for agriculture beginning in 1963, the test excavations focused on ten 1 x 1.5m squares to the north and east of the garden (Figure 2). Each square was excavated in arbitrary 10cm levels. Excavations quickly identified a lack of well-defined stratigraphic levels at the site (Figure 3). Excavated levels tended to include fragments of charcoal, ceramics, animal bone and shell, human bone, beads, metal and daub. However, based on a reconstruction of field notes it is clear that there were at least three significant features identified at NP6 (Bayard and Solheim II 2009a; Green 1965a): a burial, a cache of ceramic vessels with human cremations, and the presence of daub.

[1] According to Bayard (1971a: 70), Don Kok Pho was also tested by the “Thai-British excavations (R.H. Parker, personal communication),” but we are unaware of any published records from this work; nor do we know when it occurred (presumably after 1965).

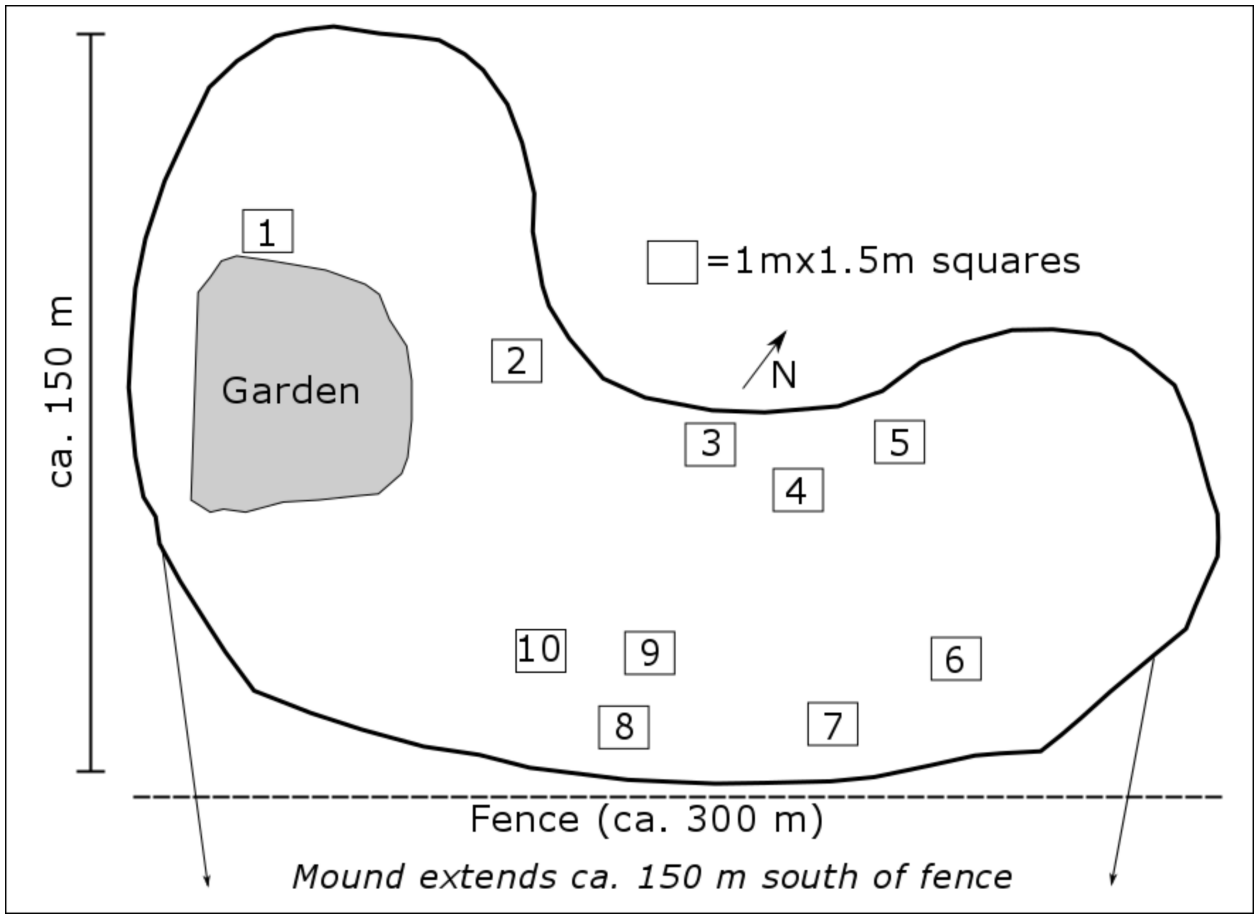

Figure 2. The NP6 mound, digitally transcribed from fieldnotes (Green 1965a). Note the location of the ten test excavation squares and the garden.

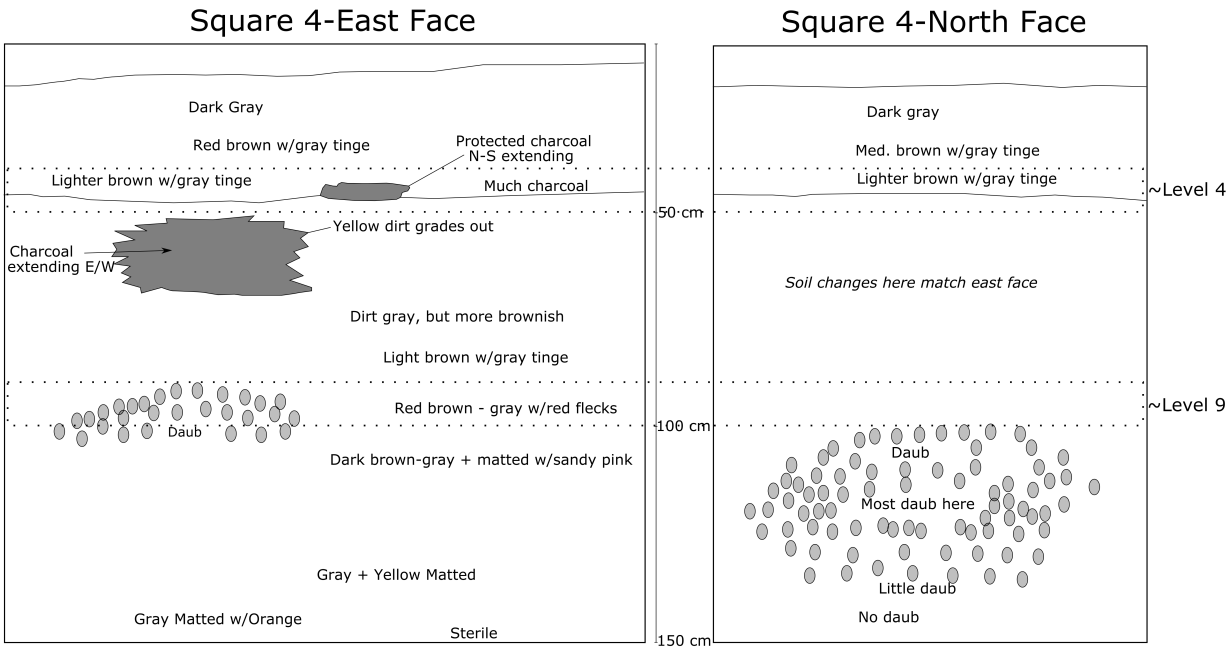

Figure 3. Stratigraphic profile for the east and north faces of test excavation square 4, digitally transcribed from fieldnotes (Green 1965a). Note the approximate levels (4 and 9) of where our radiocarbon samples derive.

In square 8, level 11, Green and Pengprecha excavated a single non-cremated burial. As Green (1965a) documented, this individual lay supine, head facing southeast, extended, and body facing east, but this burial was not placed in a formal pit. Several items were included with this inhumation, specifically an iron hoe or axe and red plainware pot directly adjacent to the left leg, and a second pot on the lower right leg. Two stones were also discovered near the cranium, fragmented pottery occurred throughout the deposit and the individual was associated with bone beads (possibly also "red beads" from square 8, level 9). Excavations in this square reached sterile deposits directly below this burial.

However, while this individual was provided a full interment, in square 10, levels 10-13, Green and Pengprecha identified a sharply contrasting burial deposit with at least 17 discrete human cremations and associated artifacts, including bronze, each within an individual ceramic vessel. These vessels included, "red cordmarked, several red incised, black cordmarked, black plain, [and] cream" types (Green 1965a). Sadly, square 10 was the last square excavated and they were unable to reach sterile deposits prior to departing. As Green (1965a) wrote, "I covered all of

the square with paper sacks + dirt. It is unfortunate that we had to leave this rich square, but we must move on."

Finally, in square 4, levels 3-4 and 9-13, excavations recovered a large quantity of daub – but daub only occurred in square 4 and nowhere else on-site. This is significant as the daub may suggest the long-term presence of a prehistoric wattle and daub structure, potentially destroyed and rebuilt between levels 9 and 4 (Figure 3; Bayard and Solheim II 2009a). A single charcoal sample was submitted for radiocarbon analysis from square 4, level 4 at Don Kok Pho, but was never published (see below). Our radiocarbon analysis included a second sample (tooth enamel) from this test excavation square in level 9.

Excavations at Don Kok Pho provided an intriguing picture of prehistoric life in northeast Thailand. Significant results included evidence for prehistoric architecture and the presence of two distinct burial practices which were potentially contemporaneous.

2.2 Non Nok Tha (NP7)

Non Nok Tha (Partridge Mound) is an open-air archaeological site and one of the first large mounds systematically excavated in Thailand (Figure 1). Originally identified through survey on May 3, 1964, the site included abundant plain and cord-marked ceramic sherds among other items (Gorman 1963-1964; Solheim II and Gorman 1966). Between January 18-February 2, 1965, Green and Pengprecha returned to Non Nok Tha and conducted a test excavation of seven squares (Green 1965b; Figure 4).

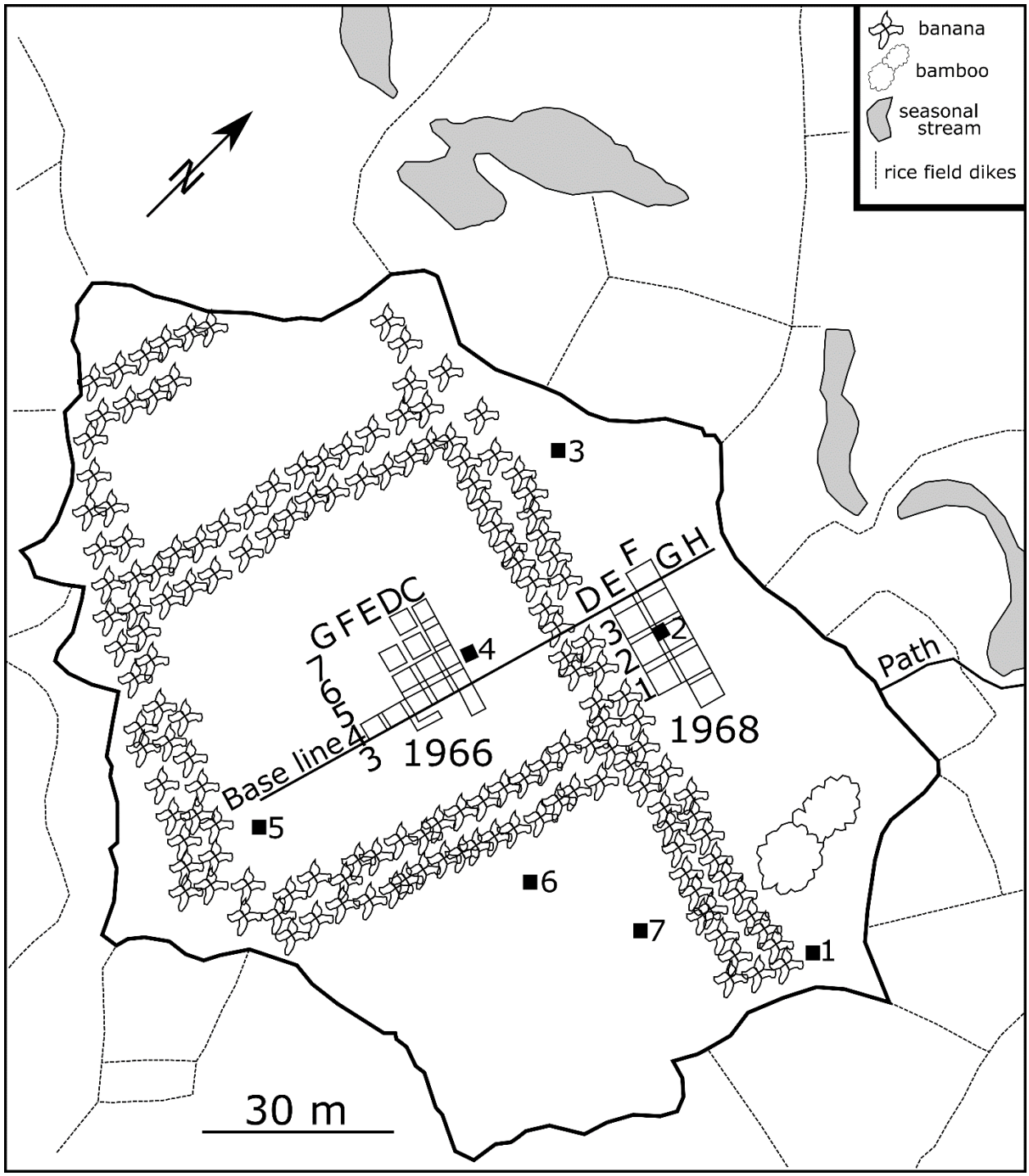

Figure 4. Overview site excavation map of Non Nok Tha showing the location of Green's 1965 test excavation squares (black squares) and the large-scale units from 1966 and 1968. Adapted from Bayard (1970).

In similar fashion to Don Kok Pho, the 1965 test excavation squares at Non Nok Tha produced inhumations, cremations in vessels, metal artifacts – including several notations of "bronze" – animal bones, shell, and ceramics. Excavation proceeded in 10 cm levels following the natural stratigraphy, and excavation squares ranged in size from 1 x 2m and 1 x 1.5m squares (Green 1965b). Excavations in one square in particular, square 6, were relatively deep, undisturbed, and reached approximately 2m below surface (Figure 5). This approximates depths reached during the 1966 and 1968 excavations at Non Nok Tha (Bayard 1971b), therefore we selected sample from this square for radiocarbon analysis.

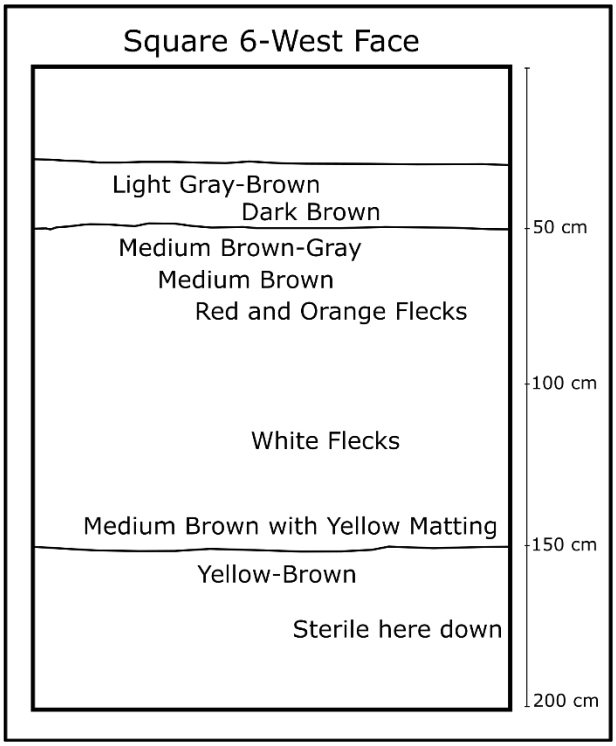

Figure 5. A profile drawing of test excavation square 6, the western face, at Non Nok Tha. Digital transcribed from fieldnotes (Green 1965b).

While the 1965 test excavations are often overlooked given the systematic large-scale excavations in 1966 and 1968, it is important to note that it was through the discoveries made by Green and Pengprecha in 1965 that the later dedicated research occurred at Non Nok Tha. Their initial investigations noted the presence of differing burial types, and a possible transition between the use of no metals (lowest levels), bronze (middle-lowest levels) and then iron (upper

levels). They also identified a painted ceramic sherd which was the first of its kind, at that time, from northeast Thailand (Bayard and Solheim 2009a; Green 1965b).

Green and Pengprecha also submitted a radiocarbon sample from their 1965 testing (see below). However, broad-scale dating of Non Nok Tha occurred only after systematic, site-wide excavations conducted by Donn Bayard, R.H. Parker and Wilhelm Solheim II over two seasons, between December 1965-April 1966 and February-May 1968 (Bayard 1970; 1971a; 1971b; 1972; Bayard and Solheim 2009a; 2009b; Solheim 1968). Radiocarbon ages and thermoluminescence measurements from the 1966 and 1968 excavations resulted in 51 determinations (Tables 1 and 2) ranging between 7871 ± 250 years BP (GaK-1032) and 500 ± 85 years BP (GX-1609). None of these ages derived from samples taken from the 1965 test excavation squares. While the excavation, analysis and dating of Non Nok Tha was significant for its time, the legacy of this record is one of controversy with the specific dates, and their interpretation(s), receiving numerous challenges over their association with human activities, accuracy and reliability (Bronson and Han 1972; Higham 1989: 99-130; 1996-1997; Higham et al. 2014; 2015; Loofs-Wissowa 1974; Reed 1977; Smith 1979; Spriggs 1996-1997; Stargardt 1981) – even in some instances by the site director himself (Bayard 1970: 130-134; 1971a: 109-119; 1971b: 26-30; 1979; 1980; 1984; 1996-1997; 2009). More recently, a direct radiocarbon analysis of human remains from the 1966 and 1968 excavations at Non Nok Tha resulted in 16 additional determinations ranging between 3146 ± 30 years BP (OxA-X-2586-17) to 2414 ± 27 years BP (OxA-30391; Higham et al. 2014; 2015; Table 1).

Unit	Layer	Level	Burial	Material	$\delta^{13}C$	Original Age ^{14}C uncal. BP	± sd	Recalculated Age ^{14}C uncal. BP	Calibrated BC/AD	Laboratory Number	Original Half-Life	Recalculated Half-Life	References
1E NE	IX kiln	LP4		Charcoal		*	-	-	-	FSU-343	5570	N/A	1
3E/3F	VIII firepit	LP3		Bamboo charcoal		*	-	-	-	FSU-339	5570	N/A	1
3F	VIII firepit	LP3		Charcoal		500	85	500	1293-1631 AD	GX-1609	5570	5568	2
D7	9	LP2		Charcoal		2220	110	-	733 BC-26 AD	GaK-958	5568	-	2
C5	9	LP2		Charcoal		2850	140	-	1406-794 BC	Gak-1026	5568	-	-
D6 SE	9	LP2		Charcoal		2480	80	-	784-409 BC	GaK-1027	5568	-	3
C7	11	LP1		Charcoal		2560	100	-	899-409 BC	GaK-1028	5568	-	2
E5	13	MP8		Charcoal		1720	80	-	133-542 AD	GaK-957	5568	-	3
4H	VII	MP6	1	Bone collagen		2564	30	-	806-567 BC	OxA-X-2586-20	5568	-	4, 5
4F	VII	MP6	24	Bone collagen		2414	27	-	738-402 BC	OxA-30391	5568	-	4, 5
2E/3E	VI	MP5	95	Charcoal		3090	120	-	1613-1014 BC	Y-2485	5568	-	2
4F	VI	MP5	17	Bone collagen		2566	27	-	806-570 BC	OxA-30394	5568	-	4, 5
3F	Layer 6U	MP4/5?		Pottery sherd organic	-24.5	3065	70	-	1496-1122 BC	OxA-2393	5568	-	6
C4	17 (or 17-18)	MP4 or MP5	Fill of 6	Charcoal		2990	110	-	1492-925 BC	GaK-1033	5568	-	2
E5	17	MP4	48	Charcoal		2830	100	-	1264-806 BC	GaK-1029	5568	-	3
G4	17-18	MP4	78?	Charcoal		3170	200	-	1927-922 BC	Y-1851	5568	-	7
4H	V (Layer 6B pit)	MP4	15	Charcoal		3685	110	3684	2454-1770 BC	GX-1611	5570	5568	2
4F/E	Layer 6B pit	MP4		Pottery sherd organic	-23.2	3285	80	-	1862-1407 BC	OxA-2390	5568	-	6
4H/E	Layer 6B	MP4	3	Charred grain	-24.3	3065	70	-	1496-1122 BC	OxA-2392	5568	-	6
2E	V	MP4	85	Bone collagen		2570	27	-	807-573 BC	OxA-X-2586-15	5568	-	4, 5
3E	V	MP4	80	Bone collagen		2505	31	-	780-523 BC	OxA-X-2586-16	5568	-	4, 5
4D	V	MP4	7	Bone collagen		2473	27	-	767-426 BC	OxA-30393	5568	-	4, 5
1F/2F	V	MP4	55	Bone collagen		2536	28	-	794-548 BC	OxA-30395	5568	-	4, 5

D5	19	MP3		Charcoal		4120	90	-	2891-2473 BC	GaK-956	5568	-	3
E5	19	MP3	48 or 55?	Charcoal		4155	200	-	3343-2204 BC	TF-651	5568	-	8
C5	18	MP3		Charcoal		<250	-	-	-	GaK-1030	5568	-	3
C4	18	MP3		Charcoal		2530	120	-	910-391 BC	GaK-1031	5568	-	2
2F	V	MP3	38	Bone collagen		2669	27	-	899-794 BC	OxA-X-2524-20	5568	-	4, 5
D6 NW	9	MP2		Charcoal		710	90	-	1158-1424 AD	GaK-908	5568	-	3
D7	20	MP2	Mound of 68	Charcoal		8100	250	-	7585-6480 BC	GaK-1032	5568	-	2
3F	I	MP2	62	Bone collagen		2717	25	-	909-811 BC	OxA-X-2524-21	5568	-	4, 5
2E	Layer 6X	MP1-4?		Pottery sherd organic	-22.2	1320	100	-	555-973 AD	OxA-2391	5568	-	6
2F	Layer 7	MP1?		Pottery sherd organic	-25.6	2880	80	-	1285-835 BC	OxA-2388	5568	-	6
3F	Layer 7	MP1?		Pottery sherd organic	-25.3	2920	80	-	1383-909 BC	OxA-2389	5568	-	6
4F SE	IV (Layer 7)	MP1		Charcoal		2470	70	2469	774-411 BC	FSU-341	5570	5568	1
D4	21	EP3	Fill of 6	Charcoal		5370	320	-	4986-3524 BC	GaK-1034	5568	-	2
1E NW	III (Layer 8U)	EP3		Charcoal		3055	65	3054	1491-1118 BC	FSU-342	5570	5568	1
?	III	EP3	90	Bone collagen		2595	95	-	923-416 BC	I-5324	?	5568	9
2E	Layer 8U	EP3	90	Bone collagen		2794	88	-	1201-804 BC	AA-1322	?	5568	10
4E/4F	Layer 8U	EP3	52	Bone collagen		1580	115	-	243-656 AD	N-1326	5568	-	11
2E	Layer 8U	EP3	90	Bone apatite		1820	220	-	358 BC-643 AD	N-1362	5568	-	11
3E/4E	III	EP3	79	Bone collagen		2788	29	-	1012-836 BC	OxA-30644	5568	-	4, 5
1E	Layer 8	EP2/3?		Pottery sherd organic	-27.7	1300	80	-	600-945 AD	OxA-2386	5568	-	6
2F	Layer 8	EP2/3?		Pottery sherd organic	-26.1	2950	80	-	1396-932 BC	OxA-2387	5568	-	6
C4	21	EP2		Charcoal		1860	140	-	174 BC-535 AD	GaK-959	5568	-	2
3E	Layer 8L	EP2	78	Bone collagen		2440	125	-	817-206 BC	N-1327	5568	-	11
2E	Layer 8L	EP2	88	Bone collagen		2420	75	-	770-393 BC	N-1328	5568	-	11

0F	II	EP2	121	Bone collagen		2911	27	-	1207-1013 BC	OxA-30360	5568	-	4, 5
3E	II	EP2	78	Bone collagen		2879	26	-	1192-935 BC	OxA-30361	5568	-	4, 5
1F/0F	II	EP2	29	Bone collagen		3059	28	-	1411-1228 BC	OxA-30392	5568	-	4, 5
1F	V	EP2	35	Bone collagen		3028	28	-	1397-1134 BC	OxA-30396	5568	-	4, 5
1F/2F	Layer 8X	EP1-2?		Pottery sherd organic	-27.9	1110	70	-	705-1119 AD	OxA-2385	5568	-	6
4G	0 (Layer 11)	EP1		Carbonized wood		4435	65	4433	3339-2917 BC	FSU-340	5570	5568	1
3E Middle	I (Layer 9)	EP1	125	Charcoal		3560	65	3559	2130-1696 BC	FSU-345	5570	5568	1
4F SW	L pit (Layer 9)	EP1		Wood charcoal		2750	130	2749	1367-545 BC	GX-1612	5570	5568	2
4F SE	Layer 9 pit	EP1		Pottery sherd organic	-26	3650	90	-	2291-1751 BC	OxA-2383	5568	-	6
4G	Layer 9	EP1		Pottery sherd organic	-26.5	3250	100	-	1864-1281 BC	OxA-2384	5568	-	6
4H	Layer 9	EP1	14	Bone collagen		6660	90	-	5732-5416 BC	AA-1321	?	5568	10
2F	Layer 9	EP1	8	Bone apatite		1010	85	-	776-1221 AD	N-1324	5568	-	11
4H	Layer 9	EP1	14	Bone collagen		2160	195	-	759 BC-235 AD	N-1325	5568	-	11
3E/3F	I	EP1	94	Bone collagen		3146	30	-	1499-1311 BC	OxA-X-2586-17	5568	-	4, 5
3E/3F	I	EP1	94	Bone collagen		3102	30	-	1436-1279 BC	OxA-X-2586-19	5568	-	4, 5

Table 1. Original radiocarbon (^{14}C) determinations (and half-lives) for Non Nok Tha. *Modern plus 0.07 counts per min per gram. sd=Standard deviation. Calibrated age ranges (at 95.4% confidence to BC/AD) reported from OxCal v4.4.2 (Bronk Ramsey 2020) using the IntCal13 atmospheric radiocarbon curve (Reimer et al. 2020) and the corrected conventional uncalibrated radiocarbon date to the 5568 half-life. Note: carbon stable isotope values are not corrected for changes in atmospheric carbon dioxide ("Suess effect"), to diet or to tissue type. [2]GaK-1026 was never published by Bayard or colleagues. This date derives from an original sample result sheet archived in the Gakushuin Laboratory database. References: (1) Daugherty et al. 1971, (2) Bayard 1970, (3) Solheim II 1968, (4)

Higham et al. 2014, (5) Higham et al. 2015, (6) Hedges et al. 1991, (7) Stuiver 1969, (8) Agrawal and Kusumgar 1968, (9) Bayard 1971a, (10) Bayard 1996-1997, (11) Yamasaki et al. 1977.

Unit	Layer	Level	Burial	Material	Age (BC)	± sd	Laboratory Number	References
C3	17	MP5	-	Pottery sherd	1120	520	PT-?	1
3E	IV (Layer 7)	MP1	73	Pottery sherd	2535	200	PT-278	2, 3, 4
3E	IV (Layer 7)	MP1	73	Pottery sherd	2350	150	PT-279	2, 3, 4
2E	III (Layer 8U)	EP3	90	Pottery sherd	2420	200	PT-276	2, 3, 4
4H	I (Layer 9)	EP1	14	Pottery sherd	2995	320	PT-277	2, 3, 4

Table 2. Original thermoluminescence ages for Non Nok Tha. Thermoluminescence ages reported in calendar years (BC). sd=Standard deviation. References: (1) Bayard 1996-1997, (2) Bayard 1971a, (3) Bayard 1971b, and (4) Bronson and Han 1972.

2.3 Don Pa Daeng (NP8)

Also known as "Red Jute Upland", this mound site was identified through survey by Gorman on May 4, 1964 (Bayard 1971a; Bayard and Solheim II 2009a; Gorman 1963-1964; see Figure 1) and was excavated by Green and Pengprecha between February 2-16, 1965 (Green 1965c). Also excavated in 10cm levels through a series of five test excavation squares measuring 2 x 1.5m (Figure 6), Don Pa Daeng included deposits that closely matched those identified at Non Nok Tha and Don Kok Pho. Inhumations, beads, animal bone, iron artifacts, and ceramics all appeared within excavated squares at this site.

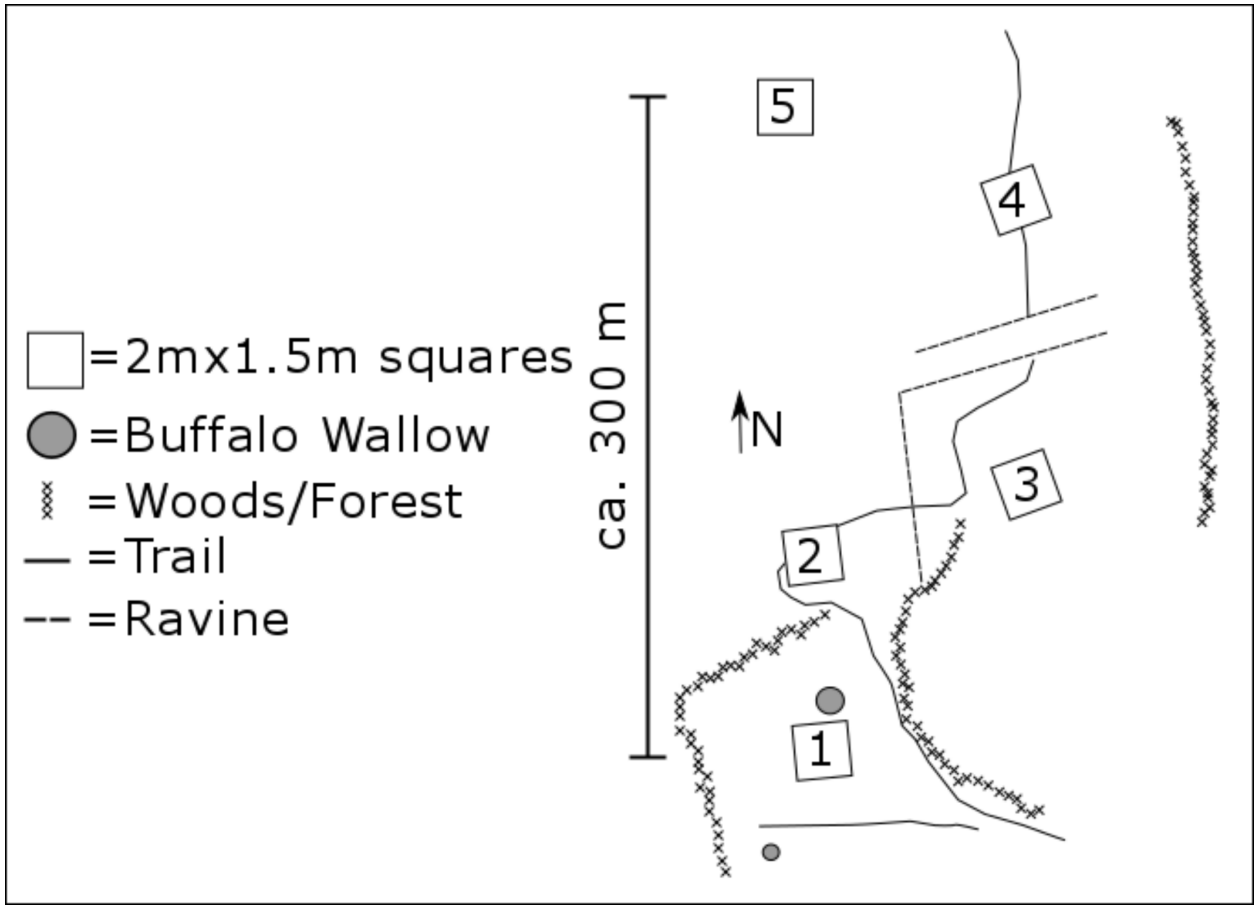

Figure 6. The NP8 mound digitally transcribed from fieldnotes (Green 1965c).

Excavations reached sterile deposits in square 1 at a very shallow depth, approximately 60cms (in level 6), but at the base of this square Green and Pengprecha discovered an extended inhumation (see Figure 7). This individual was placed in a shallow pit, and was buried with

several vessels (fragmented), beads (including glass beads), a special stone and possibly an iron hoe or axe (recovered immediately above in level 4). A second iron hoe or axe was recovered in square 3, level 5, associated with possible funerary vessels and human bones (Green 1965c). The lower levels of square 3 produced an abundance of human bone and associated vessels which suggested a possible secondary burial deposit.

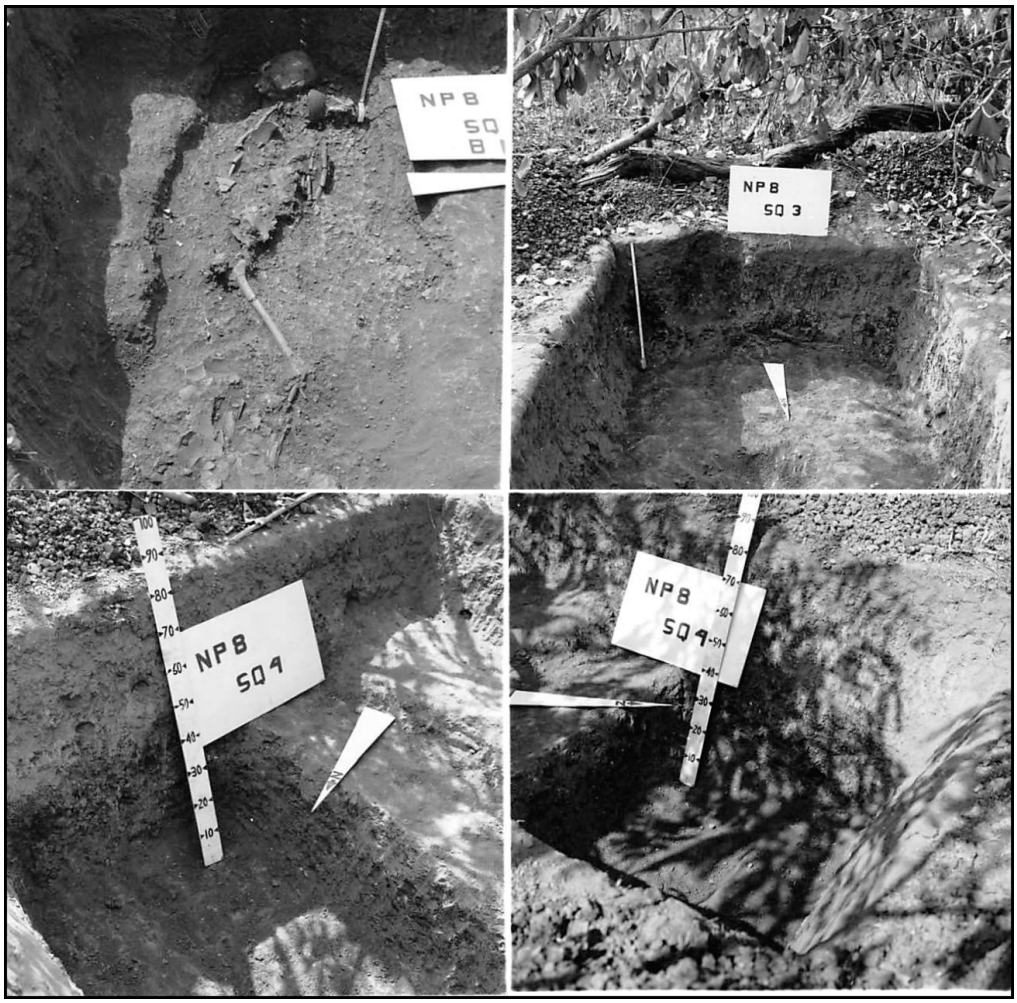

Figure 7. Photographs from the 1965 excavations at Don Pa Daeng (NP8). Top left: Excavation square 1 showing the human burial encountered in levels 5-6 (note ceramics), top right: Excavation square 3, bottom left and right: Excavation square 4 (differing views).

We selected a pig (*Sus* sp.) tooth enamel sample from square 1, level 5 (associated with the inhumation) for radiocarbon analysis to understand the temporal placement of Don Pa Daeng

within the Upper Nam Phong Watershed region chronology. We are also unaware of any submitted or previously analyzed radiocarbon samples from the 1965 test excavations at this site.

3.0 Materials and Methods

3.1 Archival Research

As part of a project focused on analyzing the Don Kok Pho, Non Nok Tha and Don Pa Daeng zooarchaeological assemblages (Conrad 2018; Franz 2017), we reviewed all available radiocarbon and thermoluminescence determinations from these sites. This involved searching through published radiocarbon dates, unpublished fieldnotes, reports and laboratory analysis letters (see Conrad et al. 2020). Since Bayard also obtained many of his radiocarbon determinations from Non Nok Tha using the Gakushuin Laboratory, Toshima, Japan, we thoroughly reviewed all available datasheets and digital reports available (in Japanese): https://www.gakushuin.ac.jp/univ/sci/top/nendai_data/html/index7.htm

Based on our archival review, we identified that a 1-gram charcoal sample was received by the Gakushuin Laboratory for radiocarbon analysis from a sample collected at Non Nok Tha on March 10, 1965, under the laboratory code GaK-654. This sample originated from Green's test square 5, layer 4. However, a review of the Gakushuin Laboratory records failed to identify the resulting radiocarbon age for this sample submission, and it does not appear in any published form of which we are aware. It is likely that this sample *i*) was never dated after submission to the laboratory (i.e., the 1-gram sample was too small), *ii*) was contaminated or modern and thus not reported, or *iii*) was dated and is now lost.

In addition, we discovered two analyzed but unpublished radiocarbon determinations – one from Green's 1965 excavations at Don Kok Pho and one from Bayard's 1966 excavations at Non Nok Tha. The Don Kok Pho 10-gram charcoal sample was received on January 14, 1965 under the laboratory code GaK-653 from "green"…"W-4-4", likely indicating that the sample originated from the west face of square 4, level 4 (see result in Table 3). The Non Nok Tha ~5-gram charcoal sample was received on July 4, 1966, under the laboratory code GaK-1026 from "NP7" unit C5, layer 9 surface (see Table 1).

3.2 Radiocarbon Samples and Methods

Radiocarbon dating in mainland Southeast Asia has a long and storied history. The 1960s saw one of the first published radiocarbon determinations from charcoal obtained from a Malaysian cave site (Dunn 1966). Since that time hundreds of radiocarbon samples from an equally large number of sites have been analyzed and interpreted (see, for example, Reynolds [1990] overview). As previously noted, Non Nok Tha was one of the first sites with an extensive radiocarbon chronology. This chronology has been the subject of much controversy, related to issues of sample contamination, preservation, and weak association between dated materials and archaeological deposits. These issues are common to radiocarbon chronologies throughout the region (see discussions in Higham et al. 2015; Oxenham et al. 2018; White 2018b).

In terms of identifying the temporal range of prehistoric human activities in mainland Southeast Asia, directly dating human bone collagen or charcoal associated with anthropogenic deposits is the preferred method. Recent developments in sample preparation techniques which provide robust contamination controls, cleaning and extraction protocols both for bone (e.g., Devièse et al. 2018; Higham et al. 2006; Zazzo and Saliège 2011) and charcoal (e.g., Higham et al. 2009) have increased the potential for accurate dating of archaeological material. However, charcoal from reliable contexts, or deposits that are directly associated with human activities, is often rare in Southeast Asian sites. In terms of bone material, in warm and moist tropical environments like northeast Thailand bone collagen is often degraded or contaminated with exogenous material which produces erroneous or spurious results.

We did not have access to charcoal samples from the 1965 test excavations. Zooarchaeological samples from the sites were extremely fragmented, uncleaned, and in some cases partially fossilized. Using the University of California, Irvine, W.M. Keck Carbon Cycle Accelerator Mass Spectrometer ultrafiltration pretreatment methods and additional XAD molecular separation techniques (see Stafford, Jr. et al. 1988) we initially attempted to extract bone collagen from two Don Kok Pho samples. One sample failed to produce any collagen after ultrafiltration and XAD preparation while a second sample produced an extremely low yield collagen measurement. A third sample from Non Nok Tha (UGAMS-33262) produced collagen but was so small that no subsequent stable isotope analysis on the parent material was possible to measure. Thus, we chose to submit bone apatite and tooth enamel samples for radiocarbon analysis rather than bone collagen.

The potential contamination and diagenesis risks associated with bone apatite and tooth enamel samples are, however, significant (Ambrose and Krigbaum 2003; Hedges and Law 1989; Stafford, Jr. et al. 1987; Zazzo 2014). While bone apatite and tooth enamel often preserve in tropical environments, carbon mixing (especially through interaction with water) often causes diagenetic changes in the bone apatite fraction (and enamel; Wood et al. 2016). This process produces radiocarbon results that may be too old or too young depending on the specific interplay between various geochemical processes. These processes function differently between, and sometimes within, sites.

However, in situations where preserved bone collagen is lacking, apatite and enamel radiocarbon dating provides one of the few means to date prehistoric deposits. The approach we use here is similar to recent radiocarbon analyses at Con Co Ngua, Vietnam, where poor organic preservation resulted in the analysis of tooth enamel, calcined antler and a seed instead of bone collagen or dentine (Oxenham et al. 2018). We selected six samples from Green's test excavations at Don Kok Pho (n=1), Non Nok Tha (n=4) and Don Pa Daeng (n=1) for radiocarbon analysis. Sample selection was based on provenience and contextual information from fieldnotes. This resulted in sampling a water buffalo (*Bubalus bubalis*) lower third molar enamel fragment from square 4, layer 9 at Don Kok Pho, a cow (*Bos* sp.) unidentified enamel fragment from square 6, layer 4, a *Bos* sp. metatarsal fragment from square 6, layer 9, and a *Sus* sp. middle phalanx fragment from square 6, layer 12 at Non Nok Tha, and a finally a pig unidentified enamel fragment from square 1, layer 5 at Don Pa Daeng.

We submitted samples selected for accelerator mass spectrometric radiocarbon dating to the University of Georgia Center for Applied Isotope Studies (UGAMS), Athens, Georgia, USA. To understand potential issues with sample contamination, we analyzed both the bone collagen and apatite fractions of the *Bos* sp. metatarsal fragment from layer 9 at Non Nok Tha. Sample pretreatment and analysis followed standard protocols (see details in Conrad et al. 2020). All radiocarbon dates are reported according to the Libby 5568-year half-life (Godwin 1962; Stuiver and Polach 1977) including all legacy dates. Calibrated age ranges (at 95.4% confidence) were obtained from OxCal v4.4.2 (Bronk Ramsey 2020) and the IntCal20 atmospheric radiocarbon curve (Reimer et al. 2020). Carbon stable isotope values were measured on the same dated material and used to correct the radiocarbon measurement for isotopic fractionation after Stuiver and Polach (1977).

4.0 Results

4.1 Don Kok Pho (NP6)

A legacy radiocarbon determination from test excavation square 4 and our newly analyzed sample produced a calibrated bracketed age range between AD 70-819 at Don Kok Pho (Table 3).

Square	Level	Material	$\delta^{13}C$	Age ^{14}C uncal. BP	± sd	Calibrated (AD)	Laboratory Number
4	4	Charcoal	-	1450	100	404-819	GaK-653
4	9	*B. bubalis* enamel apatite	-2.1	1900	25	70-215	UGAMS-41388

Table 3. Radiocarbon determinations for Don Kok Pho. Conventional radiocarbon dates corrected to 5568 half-life.

4.2 Non Nok Tha (NP7)

Radiocarbon determinations from test excavation square 6 at Non Nok Tha indicate deposits bracketed in calibrated age between 1043-386 BC (Table 4). This is a conservative range based on radiocarbon ages measured from two fractions of the same bone. Direct dates on both the collagen and apatite fraction of the *Bos* sp. metatarsal specimen suggest some contamination, either for the collagen or apatite, since the collagen fraction is substantially younger than the apatite fraction. However, the apatite dates are internally (stratigraphically) consistent between levels 4, 9 and 12.

Square	Level	Material	$\delta^{13}C$	Age ^{14}C uncal. BP	± sd	Calibrated (BC)	Laboratory Number
6	4	*Bos* enamel apatite	-4.0	2390	20	538-399	UGAMS-33261
6	9	*Bos* bone collagen*	-14.5[1]	2350	20	466-386	UGAMS-33262
6	9	*Bos* bone apatite*	-6.2	2820	20	1043-911	UGAMS-33263
6	12	*Sus* bone apatite	-7.3	2740	25	931-816	UGAMS-33264

Table 4. New radiocarbon determinations for Non Nok Tha. Conventional radiocarbon date corrected to 5568 half-life. *Both dates from the same individual bone specimen. [1]This carbon stable isotope value is obtained from the bone apatite fraction.

4.3 Don Pa Daeng (NP8)

The single radiocarbon determination obtained on unidentified pig enamel apatite from square 1, level 5 at Don Pa Daeng returned an age of 1730±25 ^{14}C uncal. B.P. (UGAMS-41389; -12.5‰ δ^{13}C) or AD 250-405 (at 95.4% confidence).

5.0 Discussion

Our radiocarbon results support a period of human occupation within the Upper Nam Phong Watershed spanning over the past 2,000 years and add to the regional record of human activities within this portion of the Phu Wiang region of the Khorat Plateau in northeast Thailand (Figure 1). In addition, these results have broader implications for the controversial radiocarbon record at Non Nok Tha and the temporal placement of Don Kok Pho and Don Pa Daeng within the Upper Nam Phong chronological record.

5.1 The Non Nok Tha Chronology

Non Nok Tha has proved to be a significant and influential example of prehistoric human activity in Mainland Southeast Asia, providing some of the earliest (in terms of scientific analysis in Thailand) evidence for domesticated pigs, cattle and water buffalo (Higham 1975) and exploitation of wild and/or potentially domesticated rice (Otsuka 1972). Excavation of bronzes at the site involved what are amongst the earliest analyses of Thai metallurgy (Bayard 1981; Pittioni 1970; Selimkhanov 1979; Smith 1973; Wheeler and Maddin 1976). The large collection of human burials at Non Nok Tha also spurred research into prehistoric paleodemography, agricultural intensification, gender structure, social complexity, grave goods (Bacus 2010; Douglas 1996a; 1996b; Douglas and Pietrusewsky 2007; MacDonald 1980; Pietrusewsky 1974a; 1974b; 2006; Ross and Oxenham 2017) and more recently – due to the large number of older adults in the burial assemblage – special aspects of burial identity for community elders (Ross and Oxenham 2016).

The radiocarbon and thermoluminescence chronology from Non Nok Tha, while contradictory and debated, indicates that this site is still an excellent example of human activities during a period of settlement, subsistence, technological and trade changes in Mainland Southeast Asia (see also White 2018a). In fact, a single burial at Non Nok Tha demonstrates the juxtaposition of its chronology well.

Burial 90, the remains of a 50-60-year-old male excavated during the 1968 season at Non Nok Tha was recovered with pottery vessels, *Sus* sp. bones, mollusk shell, and a socketed adze or tool (nicknamed "WOST – the world's oldest socketed tool; Bayard 1970; 1972; Bayard and Solheim 2009a; Douglas 1996a; Solheim 1983; Figure 8) and has four directly associated ages. These ages include two direct bone collagen radiocarbon determinations of 2595 ± 95 years BP (I-5324) and 2794 ± 88 years BP (AA-1322), a direct bone apatite radiocarbon determination of 1820 ± 220 years BP (N-1362) and a thermoluminescence measurement on a pottery sherd of 2420 ± 200 BC (PT-276). An associated radiocarbon age on charcoal from level III, layer 8 (where this individual was recovered), provides a determination of 3054 ± 65 years BP (FSU-342), while a bone collagen radiocarbon age on burial 52 (from this same level/layer) returned an age of 1580 ± 115 years BP (N-1326) and a bone collagen radiocarbon age on burial 79 (from this same level/layer) returned an age of 2788 ± 29 years BP (OxA-30644). The lack of overall consistency between each of these dated material types suggests a complex pattern of non-mutually exclusive process(es) occurring at Non Nok Tha. This potentially includes either 1) contaminated and inaccurate bone apatite ages, 2) contaminated and inaccurate bone collagen ages, 3) contaminated and inaccurate thermoluminescence measurements, 4) use of heirloom pottery vessels, 5) stratigraphic mixing of human remains or dated materials, or 6) downcutting of burial deposits into older contexts – this list is not mutually-exclusive or exhaustive.

Figure 8. Burial 90 and “WOST” at Non Nok Tha. Original site photograph by D. Bayard ca. 1968, courtesy of Dr. Joyce White and the archives at the Institute for Southeast Asian Archaeology, University of Pennsylvania Museum.

In this investigation we identified a previously unpublished legacy date (GaK-1026) and analyzed four new radiocarbon determinations from unexamined contexts at Non Nok Tha. However, our radiocarbon analysis also suffers from same problematic differences identified in material-specific investigations of individual deposits (or bone), similar to the example from Burial 90. While the *Bos* sp. metapodial bone apatite date (UGAMS-33263) is in relatively correct stratigraphic and temporal placement, the bone collagen date from this same specimen is approximately 500 years younger (UGAMS-33262). Interpreting these dates thus quickly becomes a challenging thought experiment. Since the bone collagen had a poor yield, does this suggest the date is contaminated or inaccurate? Or, is the bone collagen – even with a poor yield – providing the only accurate age for this site while the tooth enamel and bone apatite ages are inaccurate? Or, are one or more of the bone apatite dates and the tooth enamel dates accurate and/or inaccurate? This research does not attempt to solve this dilemma, it requires significant investment, including new geologic and geoarchaeological analyses of Non Nok Tha to understand potential routing of diagenetic agents. While we also hesitate to add to the confusion over an already extensively debated site chronology, we cautiously suggest that since the bone apatite dates are 1) internally consistent within this excavation square and 2) consistent with recent human bone collagen dating of Bayard's "Middle Period" at the site (Bayard 1971b; Higham et al. 2014), they are acceptable for understanding the temporal placement of this 1965 test square in the overall site record.

Furthermore, test excavation square 6 at Non Nok Tha extended to a depth of approximately 200 cm (Green 1965b; Figure 5). Given that each layer within this square was arbitrarily excavated in 10 cm levels, the radiocarbon determination from layer 4 (~40 cm) likely derives from the "light gray-brown/dark brown," sediments. The date from layer 9 (~90cm) occurs within "medium brown with yellow matting", and from layer 12, the "yellow-brown" deposits. Bayard's 1966 and 1968 (1971b) stratigraphic descriptions for this site are primarily based on the north-south running baseline extending along the profile of excavation square 4 (Figure 4). Examination of this stratigraphic sequence suggests possible similarities in sedimentary/soil descriptions for portions of the 1965, 1966 and 1968 excavation sequences – for example "soil II" which is a brown clay-loam soil occurring approximately at 50-60 cm depth (i.e., similar to the brown sedimentary deposits in square 6) – but these relationships are tentative given that the Non Nok Tha baseline and excavated squares are roughly 30 meters to the west of

test excavation square 6. Additional research is required to accurately place the test excavations within the broader context of Bayard's work.

5.2 The Upper Nam Phong Watershed Regional Chronology

A number of significant sites excavated within the Upper Nam Phong Watershed and Phu Wiang region, including Non Nong Chik, Don Klang, Non Chai and Non Pa Kluay, provide context for the newly obtained radiocarbon determinations from Don Kok Pho and Don Pa Daeng. Historically, archaeological site chronologies in this region were examined against the chronology at Non Nok Tha (Charoenwongsa and Bayard 1983; Bayard et al. 1982-1983; Buchan 1973; Schauffler 1976; Wilen 1987) – being that Non Nok Tha is the regional 'type site' for the cultural chronology of this area. Here, however, we investigate the opposite, examining the Don Kok Pho and Don Pa Daeng chronologies within the context of Non Nong Chik, Don Klang, Non Chai and Non Pa Kluay, excluding the debated chronology at Non Nok Tha.

Don Kok Pho and Don Pa Daeng both broadly date to the 1st millennium AD, but Don Pa Daeng appears to be a slightly younger site (Figure 9). Donn Bayard also correctly anticipated in his dissertation that based simply on the artifacts recovered from Don Pa Daeng, "[t]he site seems to correspond in general to the upper occupation at Don Kok Pho" (1971a: 71). Regionally, this is consistent with a pattern of a later phase of occupation throughout this region when iron production and use is more prominent. Habitation and/or cemetery sites located in this portion of the Khorat Plateau tend to appear throughout the 2nd-1st millennia BC, but their artifact assemblages often show differences with later-dating sites (or contexts within sites). During the earlier phase of occupation, including at Non Nong Chik, Non Pa Kluay and Non Nok Tha, there appear to be consistent patterns in pottery manufacture, types, and bronze (Buchan 1973; Bayard 1977; Wilen 1987), but there is a transition in both pottery manufacture, metal exploitation and regional trade networks by the 1st millennium AD (Charoenwongsa and Bayard 1983; Bayard et al. 1982-1983). Don Kok Pho and Don Pa Daeng both exhibit evidence of inhumation and cremation burials, including within vessels, and the presence of iron hoe or axe grave goods and beads. In the case of Don Pa Daeng, this also included the presence of glass beads. Don Klang and Non Chai both exhibit similar artifact records and also date to this period (Charoenwongsa and Bayard 1983; Bayard et al. 1982-1983; Hurst and Lawn 1984; Schauffler 1976).

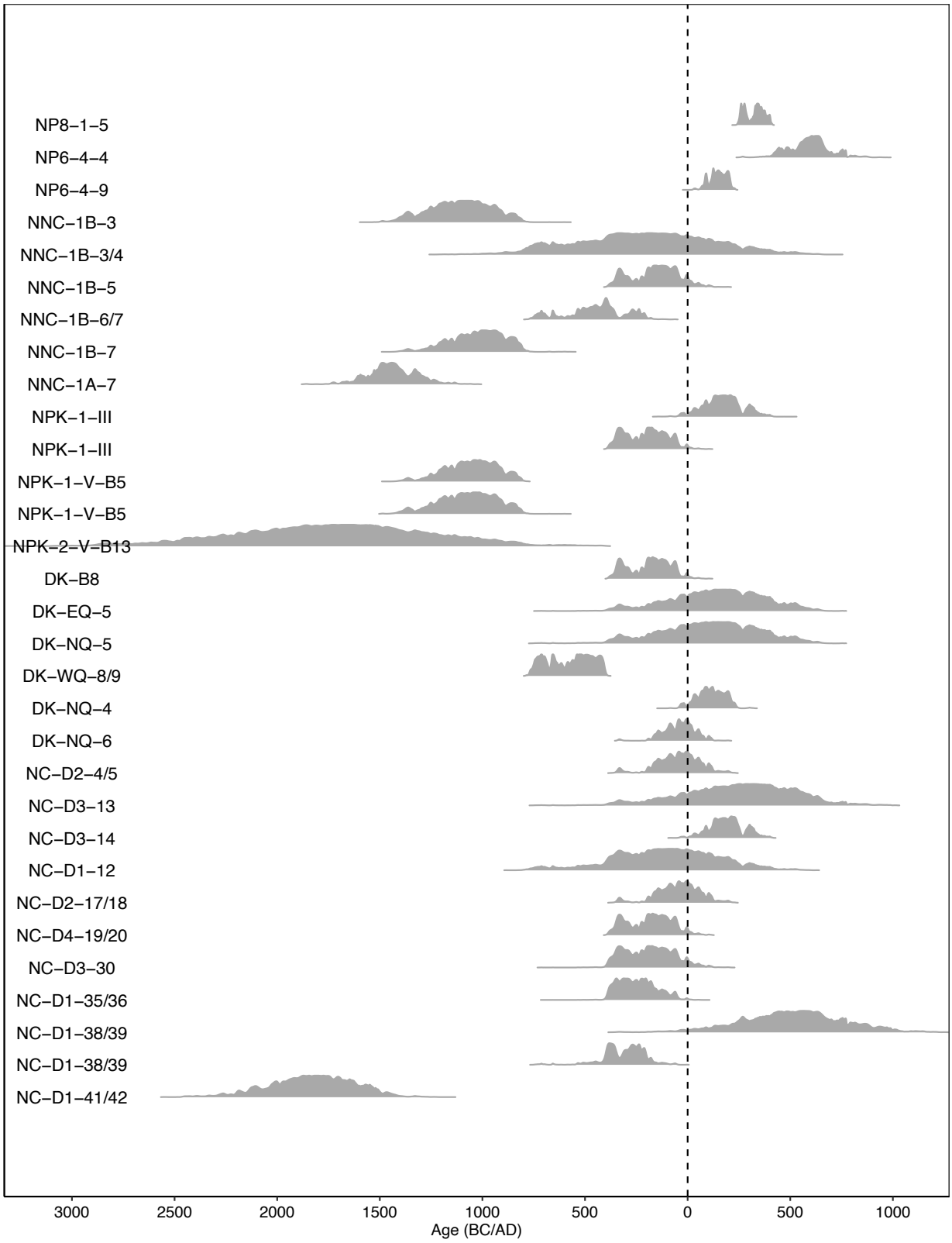
NP8–1–5
NP6–4–4
NP6–4–9
NNC–1B–3
NNC–1B–3/4
NNC–1B–5
NNC–1B–6/7
NNC–1B–7
NNC–1A–7
NPK–1–III
NPK–1–III
NPK–1–V–B5
NPK–1–V–B5
NPK–2–V–B13
DK–B8
DK–EQ–5
DK–NQ–5
DK–WQ–8/9
DK–NQ–4
DK–NQ–6
NC–D2–4/5
NC–D3–13
NC–D3–14
NC–D1–12
NC–D2–17/18
NC–D4–19/20
NC–D3–30
NC–D1–35/36
NC–D1–38/39
NC–D1–38/39
NC–D1–41/42
3000
2500
2000
1500
1000
500
0
500
1000
Age (BC/AD)

Figure 9. Calibrated radiocarbon determinations from sites within the Upper Nam Phong Watershed. Calibrated age ranges were obtained from Bchron (Parnell 2020) and the IntCal20 atmospheric radiocarbon curve (Reimer et al. 2020; see Conrad et al. 2020 for source code). Vertical dashed line represents year 0 on the Gregorian calendar. See Non Nong Chik (NNC; Buchan 1973), Non Pa Kluay (NPK; Wilen 1987), Don Klang (DK; Hurst and Lawn 1984) and Non Chai (NC; Charoenwongsa and Bayard 1983; Bayard et al. 1982-1983) for originally published radiocarbon determinations. The Non Pa Kluay Level V, Burial NPK-5 dates derive from two determinations from the same burial context (see Wilen 1987).

6.0 Conclusions

Identifying the correct placement of the test excavation deposits at Don Kok Pho, Non Nok Tha and Don Pa Daeng in the Upper Nam Phong Watershed chronological sequence is important given that these sites remain to be systematically and fully excavated and have curated test-excavation collections which are not fully analyzed (see Section 6.1). While Non Nok Tha dates to the 1st millennium BC, both Don Kok Pho and Don Pa Daeng date to the 1st millennium AD. Although large-scale investment in archaeological research within the Khorat Plateau has moved away from the Upper Nam Phong Watershed in recent decades, this area still holds remarkable potential for helping understand the processes and transitions in prehistoric human activity and behavior within northeast Thailand.

6.1 A Note on the NP6, NP7 and NP8 Collections

Green's 1965 test excavation material was originally stored in the Department of Anthropology at the University of Hawai'i at Mānoa (UH) in what was known as the Solheim Collections. These collections included materials from multiple sites in northeast Thailand. Portions of the Non Nok Tha assemblage in the Solheim Collections also included materials from the 1966 and 1968 excavations. The UH also curated a large collection of now digitized records, including photographs, reports and fieldnotes from Non Nok Tha and associated sites. Our radiocarbon samples from Don Kok Pho, Non Nok Tha and Don Pa Daeng were obtained through a long-term zooarchaeological research loan from the UH to the University of New Mexico, Maxwell Museum of Anthropology to C.C. as part of his dissertation research. In 2017, the UH voluntarily repatriated the Solheim Collections to the Thailand Fine Arts Department/Ban

Chiang Museum in Udon Thani Province, Thailand. In 2019, C.C. also returned the zooarchaeological research loan specimens to the Thailand Fine Arts Department/Ban Chiang Museum. The physical Non Nok Tha photographs and records were transferred from the UH and are now permanently curated at the American Heritage Center at the University of Wyoming – prior to Solheim's passing he helped established this permanent archive in his name. In addition to these locations, portions of the Non Nok Tha human and animal bone collections are located at the University of Nevada, Las Vegas, Nevada (human), the Department of Anatomy, University of Otago, New Zealand (human and animal), and the Siriraj Piyamaharajkarun Hospital, Bangkok, Thailand (human). Finally, several of the Non Nok Tha bronze mounts are still located at the Penn Museum, University of Pennsylvania, Philadelphia, Pennsylvania, where they were sent after initial analysis by Smith (1973) at the Massachusetts Institute of Technology, Cambridge, Massachusetts. It is also possible that carbonized rice specimens are still located at the Kihara Institute for Biological Research, Yokohama, Japan from Non Nok Tha.

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