POSTCLASSIC PETÉN MAYA BOW-AND-ARROW USE AS REVEALED BY IMMUNOLOGICAL ANALYSIS

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Abstract

The bow-and-arrow was a widely used weapon in the Postclassic and Contact periods in the Maya lowlands. A sample of 108 arrow points from varied archaeological contexts in the lakes region of central Petén, northern Guatemala, was submitted for cross-over immunoelectrophoresis (CIEP) analysis. Analysis resulted in 25 positive matches to available antisera for a wide range of local and introduced fauna, from small and large land mammals to avians. These findings indicate possible uses in subsistence and ritual, as well as the first immunological identification of human proteins from projectile weaponry in Mesoamerica. This study did not reveal strong correlations between targeted fauna and point morphology, although larger points were likely used for larger game.

Keywords: Cross-over immunoelectrophoresis, protein residue analysis, Postclassic Maya, Petén, projectile weaponry

1. Introduction

Small projectile points are one of the most common formal stone tools in Postclassic lithic assemblages in the Maya lowlands of southern Mexico, northern Guatemala (Department of El Petén), and Belize. These points, generally 1 to 3 cm long and weighing 0.25 to 1.0 g, are typically side-notched, with varying base and hafting styles (Fig. 1; Meissner 2014: 237–352). Functionally, they are “arrowheads,” hafted to slender shafts. Despite several studies of these points (Blake 2010; Graham 1991, 2011; Masson 2000; Oland 2013; Proskouriakoff 1962; Shafer and Hester 1988; Simmons 1995, 2002), little research has attempted to reconstruct their actual uses in hunting, warfare, or other activities, through archaeological data.

Fig. 1. Examples of small obsidian arrow points from the Petén lakes region. Note impact-damaged specimens in bottom row.

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This study used cross-over immunoelectrophoresis (CIEP), an immunological method for identifying protein residues, to investigate point use: specifically to determine fauna hunted using the bow-and-arrow. The sample of 108 analyzed points, largely made from obsidian, comes from Late Postclassic (ca. AD 1400–1525) and (Spanish) Contact (AD 1525–1697) period sites in Petén. Residue analysis addressed several questions related to use of these points in subsistence, ritual, and defensive behavior.

2. Background

2.1. *The Postclassic Petén lakes region*

The “lakes region” of the Department of Petén refers an east-west chain of eight lakes in northern Guatemala (see Fig. 2 inset). Continually occupied since the early Middle Preclassic period (ca. 800 BC) and probably well before, the lake basins’ defensible islands and peninsulas became a settlement focus beginning in the Terminal Classic (ca. AD 800–950/1000). The arrow points analyzed here came from archaeological excavations into Late Postclassic and Contact period contexts at five sites in the western portion of the lakes chain: Nixtun-Ch’ich’, Tayasal, Quexil, Ixlú, and Zacpetén.

Fig. 2. Detail of the Petén lakes region with sites and ethno-political affiliations marked (redrawn and modified from Pugh et al. 2012:4, Figure 1).

Lake Petén Itzá, the largest of the lakes, was controlled by the Itzas from their island capital at Nojpeten (modern Flores) until Spanish conquest in 1697, after which the island became a garrison (Jones 1998). Nixtun-Ch’ich’ was ruled by the Chak’an Itzas, which became an opposing faction sometime in the seventeenth century or before. The points analyzed here come from the peninsular part of the site, specifically Mound ZZ at its eastern tip (Rice 2009),

location of the early eighteenth century Spanish mission San Jerónimo. Tayasal occupies the western Tayasal Peninsula, where two additional Spanish missions were established. The site of Quexil (Schwarz 2004) comprises two islands in small Lake Quexil, south of the main arm of Lake Petén Itzá.

To the east, Ixlú occupies a narrow isthmus separating Lakes Petén Itzá and Salpetén. Ixlú was an Itza port, but in the late seventeenth century it was contested by their eastern enemies, the Kowoj, allied with the Chak'ans against the ruling Itzas of Nojpeten (Rice and Rice in press). The Kowoj had an important settlement with two distinctive “temple assemblage” civic-ceremonial complexes and a possible *popol naj* or council house at the nearby peninsular site of Zacpetén in Lake Salpetén (Pugh 2001, 2003; Rice and Rice 2009).

2.2. Ethnohistorical and ethnographic accounts

Written accounts from the sixteenth and seventeenth centuries describe bow-and-arrow use in Petén primarily in the context of defense and resistance to Spaniards (see Jones 1998: 50, 135–136). To the north in Yucatán, Franciscan Father Diego de Landa (in Tozzer 1941) concluded that the bow-and-arrow was rarely used for hunting forest creatures. Instead, it was used in coastal lagoons to shoot fish in the shallows. Secondary sources, such as Diego López de Cogolludo (2006 [1688]: Lib. IV, Cap. 5) mention hunting birds, stating the Maya “shoot with their arrows peacocks, some birds they call *phaysanes*, and many others.”

Arrows may have been used in hunting rituals during the early Contact period: hunters gathered in a house, the house was blessed and evil spirits removed, and an altar was prepared (Landa [in Tozzer 1941]: 153–155). Hunters offered copal incense while summoning deities associated with the pursuit of game; afterward, they removed arrows from their quivers and danced with blue-painted deer skulls. Some participants used their arrows to pierce their ears and tongues and let blood. Other ritual uses include “arrow sacrifice” of Spaniards in Champotón and Ixpimienta, in which an individual was tied to a tree and ceremoniously killed by arrows (Jones 1989: 221). Padre Pedro Sánchez de Aguilar mentioned rituals in Cozumel that included a “dance of their paganism, and while dancing they shoot with arrows a dog which they are to sacrifice” (Roys et al. 1940: 6).

Ethnographic research among the Lacandon Mayas revealed lexical distinctions among sizes and types of arrow points, often based on the type of animal hunted. “Barbed arrows” were used for monkey hunting (Baer and Merrifield 1971: 236; Boremanse 1998: 73; Nations 1989: 456), while “bird bolts” were wooden arrow tips with wide shoulders (Nations 1989: 456; Tozzer 1907: 59). Larger stone-tipped arrows were used for defensive purposes or for big game, such as peccaries or deer (Boremanse 1998: 84; Nations 1989: 456), while certain wooden arrow tips were for bow-hunting fish (Nations 1989: 454). Blunted arrow tips were used by children to shoot down tree fruits without penetrating the skin (Barrera 2005: 33).

3. Methods and Materials

CIEP, developed in forensic science, has been refined over the last thirty years and has had relative success in archaeological applications to residues on artifacts (Yohe and Stephens 2014; see Kooyman et al. 2001; Newman et al. 1997; Newman and Julig 1989; Seeman et al. 2008; Yohe et al. 1991). Proteins readily bind to stone tools as siliceous material is typically negatively charged and attracts positively charged protein substances (Newman et al. 1997: 1023). Because

CIEP uses immunological data, chances for false positives and soil contamination are minimized (Kooyman et al. 1992; Petraglia et al. 1996: 128; Seeman et al. 2008: 2745). However, soil contamination from tannins, humic acids, and bacteria could hypothetically produce a false positive if such materials contacted stone tools (Gurfinkel and Franklin 1988; Shanks et al. 1999; Seeman et al. 2008). Typically, archaeological soil samples are tested alongside samples submitted for CIEP analysis. One limitation of the current study is that the tested points were recovered from excavations occurring as much 20 years earlier, thus lacking a soil sample referent. Thus, future excavations of Petén lakes sites should include CIEP soil referents to control for contamination.

Our sample of Maya arrow points was analyzed at the Laboratory of Archaeological Science at California State University Bakersfield under the direction of Robert Yohe II. A list of the various antisera and potential positive reactions to various fauna is provided in Table 1. All commercial antisera originated from Cappel Research (now acquired by MP Biomedicals), Lampire Biomedical, and Cedarlane Laboratories (Yohe and Stephens 2014: 2). To allow for greater replicability of this study, additional data concerning the commercial preparation of antisera are provided (see Inline Supplementary Material). CIEP is limited to the types of commercially available antisera, and thus specific local Petén fauna such as monkeys, armadillos, and perciform fish may be too genetically distant to react with any commercial antisera.

Table 1. Types of antisera and proposed reactions (redrawn from Yohe and Stephens 2014:Table 2)

Antiserum type	Positive reactions	Antisera Manufacturer
Alligator	alligator, crocodile	Cappel Research
Bear	black bear, grizzly, and others	Cappel Research
Bovine	bison, cow, musk ox	Cappel Research
Camel	all camelids (New and Old World)	Cappel Research
Cat	bobcat, cougar, lynx, and others	Cappel Research
Chicken	quail, grouse, and other gallinaceous fowl	Cappel Research
Deer	deer, elk, moose	Cappel Research
Dog	coyote, wolf, domestic dog	Cappel Research
Elephantidae	elephant, mammoth, mastodon	Lampire Biomedical
Guinea-pig	beaver, guinea-pig, porcupine, squirrel	Cappel Research
Horse	horse, donkey, kiang, and others	Lampire Biomedical
Human	human	Cappel Research
Rabbit	rabbit, hare, pika	Cappel Research
Rat	all rat and mouse species	Cappel Research
Sheep	bighorn and other sheep	Cappel Research
Pig	swine, possibly peccary	Cappel Research
Trout	trout and salmon species	Cedarlane Laboratories

3.1. *Extraction and Identification Methods*

Proteins bound to an artifact are extracted by submersing the object in a 5% ammonia hydroxide

solution and applying ultrasonic pulses for 5 minutes. The artifact and ammonia solution are then placed in a rotating mixer and left for 30 minutes. Extracted solutions are entered into sterile vials and frozen at -20°C (Yohe and Stephens 2014: 1–2). For analysis, the solutions are placed into wells formed from agarose gel, with animal antisera introduced into the opposite side of the well. An electrical current is run through the gel to observe whether the extracted residue (consisting of antigens) attracts to the antibodies (Yohe and Stephens 2014: 2). If a positive reaction occurs, the result is a semi-solid mass of precipitate (Odell 2004: 167). Such precipitate patterns can be observed after the gel is pressed, dried, and stained (Yohe and Stephens 2014: 2).

Positive identifications of immunological reactions primarily occur at the level of an organism's family in Linnaean biological taxonomy. Species identification through CIEP is not possible in all cases (Newman et al. 1997: 1025) and immunological responses may not have an exact correspondence with Linnaean taxa. For example, positives for rat may represent a broad range of rodents, as sciurid (squirrel) proteins could test positive for rat antiserum (Newman et al. 1997: 1025). Additionally, it is impossible to distinguish between goat and sheep antiserum reactions (ibid.). If few species are represented locally, it may be possible to narrow the results to local species.

Like any instrumental method, protein analysis is not without its limitations and potential drawbacks (see Barker et al. 2012: 409–410). CIEP analysis can only offer positives for remaining (preserved) proteins. Negative results may mean the point was unused, or that any proteins once present are too degraded to extract and identify. Importantly, positive reactions for a particular species do not necessarily rule out the possibility that an artifact was used on other species as well. Thus, if a point was used for both deer and peccary, degradation could in principle affect one species' protein and not the other.

Another limitation of CIEP is cross-contamination and the potential for false positives. A problematic issue is the potential for cross-reactive responses resulting in identification of an animal that is irreconcilable with local faunal types (Fiedel 1996: 139). However, improved methods of antisera preparation in the last decade may have reduced the number of false positives associated with CIEP (Malainey 2011: 219). In this study, a control of fresh animal protein was run alongside each positive test to verify precipitate results (Yohe 2010: 2).

Post-depositional washing of artifacts does not appear to remove all proteins, leaving a high likelihood that at least some material will be available for detection (Lee and DeForest 1976). It is hypothesized that the amount of degradation of a particular protein due to age does not necessarily affect the detection process as long as epitopes are intact (Gaensslen 1983: 225; Gilbert et al. 2008: 787–788). However, it is important to note that the identification of certain proteins can be hindered largely by protein denaturation, especially in cases where proteins are heated (Barnard et al. 2007a: 35; Barnard et al. 2007b: 217).

3.2. *Materials*

A sample of 108 arrow points from five sites in the Petén lakes region was selected for CIEP analysis. All artifacts had been touched during the process of excavation and lab processing, but they were not washed with soap and water or scrubbed intensively. None had indications of thermal damage that would prevent identification of remaining proteins. Samples were selected through a stratified sampling protocol designed to address issues of point use varying with raw material type, point morphology, depositional context, and site (Table 2). Sampling favored contexts and use-damaged specimens over raw material type, and the resulting sample was

largely obsidian due to the high frequency of obsidian point manufacture in the subregion (Meissner 2014: Table 5.1). Contextually, the samples represent domestic, civic-ceremonial, and defensive structures or areas. Concerning raw materials, 105 points were of obsidian. Source flows for 90 specimens were determined by PXRF analysis (see Meissner 2014: 136; Rice and Cecil 2009: 334) and included San Martín Jilotepeque ($n = 38$), Ixtepeque ($n = 27$), and El Chayal ($n = 23$) from highland Guatemala, plus Pachuca ($n = 1$) and Pico de Orizaba ($n = 1$) from central Mexico.

Table 2. Data on 108 projectile points submitted for CIEP analysis

Site	n =	Structures			Positives	Individual Reactions
		Sampled	Obsidian	Chert		
Zacpetén	41	7	41	0	13	18
Ixlú	11	6	11	0	0	0
Quexil	9	6	7	2	0	0
Tayasal	5	4	5	0	0	0
Nixtun-Ch'ich'	42	10	41	1	12	19
Totals	108	33	105	3	25	37

4. Results

Of the 108 points submitted for analysis, 25 specimens (23.1%) tested positive for animal proteins. These came from only two of the five sites: Nixtun-Ch'ich' and Zacpetén. Reasons for this difference of preservation of proteins are unclear considering that the Petén lakes sites had similar vegetation cover (deciduous tropical forest) and soil composition derived from interbedded limestone, dolomite, and gypsum bedrock. The site of Quexil is located in a small area of Exkixil soils, which are clayey with poor drainage (Simmons et al. 1959: Cuadro 104). The other sites are all on Yaxá soils: clayey with good drainage (ibid.). The site of Zacpetén occupies a peninsula in Lake Salpetén, which is underlain by gypsum and its brackish waters are high in sulfur (Rosenmeier et al. 2002: 184). Additionally, recovery contexts randomly varied by depth and structure type (see Meissner 2014:431–462 for detailed discussion of contexts). The vast majority of positives from Zacpetén and Nixtun-Ch'ich' were located in the interior of structures or discarded close to the back walls. It is possible that temporary protection from the elements and structural collapse may have increased the likelihood of protein preservation, but larger samples are needed to reach any conclusions.

A list of antisera reactions and likely local Petén fauna is displayed in Table 3. Positives included at least 11 different family level reactions, and several points had multiple reactions, contributing to a total of 37 positives to available antisera (Table 4; negative responses are documented in Meissner 2014: Tables 7.66 and 7.68). Points lacking positive reactions may have had proteins too degraded to detect or possibly were never actually used.

Table 3. List of immunological reaction types and most probable Petén species

Positive Reaction	Most Probable Petén Species
Bear	Unknown, White-nosed coati (<i>Nasua narica</i>)? Kinkajou (<i>Potos flavus</i>)? West Mexico black bear (<i>Ursus americanus machetes</i>)? false positive?
Bovine	Cow (<i>Bos primigenius</i>), false positive? Contact period?
Cat	Jaguar (<i>Panthera onca</i>), jaguarundi (<i>Puma yagouaroundi</i>), ocelot (<i>Leopardus pardalis</i>) margay (<i>Leopardus wiedii</i>)
Chicken	Ocellated turkey (<i>Meleagris ocellata</i>), spotted wood quail, singing quail, ocellated quail
Deer	White-tailed deer (<i>Odocoileus virginianus</i>), red brocket deer (<i>Mazama temama</i>)
Dog	Gray fox (<i>Urocyon cinereoargenteus guatemalae</i>), coyote (<i>Canis latrans goldmani</i> subspecies), domesticated dog (<i>Canis familiaris</i>)?
Human	Human (<i>Homo sapiens</i>)
Rabbit	Forest cottontail (<i>Sylvilagus brasiliensis</i>), eastern cottontail (<i>Sylvilagus floridanus</i>)?
Rat	Various cricetidae, lowland paca? (<i>Cuniculus paca</i>)
Sheep	Sheep (<i>Ovis aries</i>), goat (<i>Capra hircus</i>), false positive?, Contact period?
Swine	Collard peccary (<i>Pecari tajacu</i>), white-lipped peccary (<i>Tayassu pecari</i>)
Rat	Various cricetidae, lowland paca? (<i>Cuniculus paca</i>)
Sheep	Sheep (<i>Ovis aries</i>), goat (<i>Capra hircus</i>), false positive?, Contact period?
Swine	Collard peccary (<i>Pecari tajacu</i>), white-lipped peccary (<i>Tayassu pecari</i>)

Table 4. Positive CIEP results and contextual information for small obsidian projectiles

Site	Point ID	Str./Op.	Lot	Unit N	Unit E	CIEP Reaction	Most probable Petén Species
Nixtun-Ch'ich'	21862	ZZ1	41920	5039	5639	Bovine	Cow (Contact period, false positive?)
Nixtun-Ch'ich'	21867	DD-2	42618	P. 20	-	Bovine	Cow, (Contact period, false positive?)
Nixtun-Ch'ich'	21856	ZZ1	41864	5040	5634	Cat	Jaguar, jaguarundi, ocelot, margay
Nixtun-Ch'ich'	20605	ZZ1/2	42520	5073	5585	Deer	White-tailed deer, red brocket deer
Nixtun-Ch'ich'	20631	ZZ1/1	41771	5050	5619	Deer	White-tailed deer, red brocket deer
Nixtun-Ch'ich'	21846	ZZ1/2	42535	5068	5584	Dog	Gray fox, coyote, domesticated dog?
Nixtun-Ch'ich'	21848	ZZ1/1	45036	5048	5642	Dog	Gray fox, coyote, domesticated dog?
Nixtun-Ch'ich'	21849	ZZ1/1	45016	5049	5640	Dog	Gray fox, coyote, domesticated dog?
Nixtun-Ch'ich'	21850	ZZ1/1	41620	5049	5639	Dog	Gray fox, coyote, domesticated dog?
Nixtun-Ch'ich'	21851	ZZ1/1	45091	5051	5643	Dog	Gray fox, coyote, domesticated dog?
Nixtun-Ch'ich'	21852	ZZ1/1	41583	5053	5638	Dog	Gray fox, coyote, domesticated dog?
Nixtun-Ch'ich'	21849	ZZ1/1	45016	5049	5640	Rabbit	Forest cottontail, eastern cottontail?
Nixtun-Ch'ich'	21850	ZZ1/1	41620	5049	5639	Rabbit	Forest cottontail, eastern cottontail?
Nixtun-Ch'ich'	21851	ZZ1/1	45091	5051	5643	Rabbit	Forest cottontail, eastern cottontail?
Nixtun-Ch'ich'	21849	ZZ1/1	45016	5049	5640	Rat	Various cricetidae, lowland paca?
Nixtun-Ch'ich'	21850	ZZ1/1	41620	5049	5639	Rat	Various cricetidae, lowland paca?
Nixtun-Ch'ich'	21851	ZZ1/1	45091	5051	5643	Rat	Various cricetidae, lowland paca?
Nixtun-Ch'ich'	21854	ZZ1	45126	5056	5641	Rat	Various cricetidae, lowland paca?
Zacpetén	21011	732	11540	99	407	Bear	Unknown, White-nosed coati? Kinkajou?
Zacpetén	21009	732	11468	101	414	Bear	Unknown, White-nosed coati? Kinkajou?
Zacpetén	21008	732	11386	106	405	Bear	Unknown, White-nosed coati? Kinkajou?
Zacpetén	21007	747	10616	702	193	Bear	Unknown, White-nosed coati? Kinkajou?
Zacpetén	21022	664	17291	293	601	Bear	Unknown, White-nosed coati? Kinkajou?
Zacpetén	21021	664	17176	306	592	Bear	Unknown, White-nosed coati? Kinkajou?
Zacpetén	21014	721	12179	685	329	Cat	Jaguar, jaguarundi, ocelot, margay
Zacpetén	21007	747	10616	702	193	Cat	Jaguar, jaguarundi, ocelot, margay
Zacpetén	21005	747	10548	702	197	Cat	Jaguar, jaguarundi, ocelot, margay
Zacpetén	21022	664	17291	293	601	Cat	Jaguar, jaguarundi, ocelot, margay
Zacpetén	21021	664	17176	306	592	Cat	Jaguar, jaguarundi, ocelot, margay
Zacpetén	21013	721	12211	679	327	Chicken	Ocellated turkey, various quail?
Zacpetén	21005	747	10548	702	197	Chicken	Ocellated turkey, various quail?
Zacpetén	21037	614	7290	391	396	Dog	Gray fox, coyote, domesticated dog?
Zacpetén	21080	664	17059	306	596	Human	Human
Zacpetén	21082	605	5367	521	599	Human	Human
Zacpetén	21008	732	11386	106	405	Sheep	Sheep, goat (Contact period, false positive?)
Zacpetén	21029	602	5258	498	602	Swine	Collard peccary, white-lipped peccary
Zacpetén	21021	664	17176	306	592	Swine	Collard peccary, white-lipped peccary

At Nixtun-Ch'ich', the most frequently identified mammal proteins were dog (n = 6 reactions), rat (4), rabbit (3), deer (2), bovine (2), and cat (1). Multiple reactions were noted on three points, each testing positive for dog, rabbit, and rat. All other reactions at Nixtun-Ch'ich' were to single antisera. At Zacpetén, 19 immunological reactions from obsidian points included bear (likely coatimundi; n = 6), cat (5), chicken (2), swine (2), dog (1), and sheep (1), plus human (2). The implications of a positive for bear and potential cross-reactions are discussed in section 4.2. Many points from Zacpetén provided multiple reactions (see Table 4).

5. Discussion and Interpretation

5.1. Probable CIEP identifications

5.1.1. Cat

Reaction to cat antisera on one point from Nixtun-Ch'ich' and five from Zacpetén suggest contact with jaguar (*Panthera onca*), jaguarundi (*Puma yagouaroundi*), ocelot (*Leopardus pardalis*), or margay (*Leopardus wiedii*). Felines, particularly jaguars, carried rich political and religious symbolism for the Mayas (Saunders 1994): the jaguar was lord of the Underworld and rulers adorned themselves with jaguar pelts, paws, tails, claws, and teeth (Miller and Taube 1993: 102). Maya hunters may have consumed jaguar meat, blood, and ground-up claws prior to outings (Schlesinger 2001: 165). At Mayapán, feline elements were not necessarily restricted to the elite, as cat remains were found outside the ceremonial core (Masson and Peraza Lope 2008: 174).

Only one specimen from Nixtun-Ch'ich' tested positive for cat. This comparatively large arrow tip of SMJ obsidian was found in refuse on the south side of Mound ZZ1, probably a product of hunting (Meissner 2014: 444–445).

At Zacpetén, positive results for cat came from points recovered from Str. 721, 747, and 664 (Fig. 3). One comparatively small SMJ point came from behind Str. 721, a small temple associated with Str. 719 (possibly a council house), the two structures thought to be part of the final elite occupation of the site (Pugh et al. 2009). Two points of Ixtepeque obsidian testing positive for cat were from the back room of large residential Str. 747. One had unrepaired impact damage, suggesting that the point was discarded after removal from the haft (Meissner 2014: 445–446). The second specimen also reacted with chicken antisera, suggesting contact with avian proteins and multiple uses. The presence of both proteins suggests the residents of Str. 747 were actively involved in procuring fauna, supported by the recovery of a jar holding fishing net weights and an ichthyotoxin in the back room of Str. 747.

Fig. 3. Plan view of Group 719, Zacpetén, with location of point testing positive for cat (modified with permission from Pugh 2001:471, Figure 9-9).

Two points of El Chayal obsidian from domestic Str. 664 tested positive for cat, one near the back room and the other in a patio between the residence and Str. 799 (a small altar or shrine). Both had stunted tips, suggesting they were resharpened in the haft over their use life (Meissner 2014: 446–447). The point was likely retrieved following its firing to reuse the arrow shaft, and may have been brought back to the structure along with a carcass.

5.1.2. *Chicken*

Two points from Zacpetén tested positive for chicken antiserum, which might be a broader match for various ground birds and gallinaceous fowl, especially turkey, consumed domestically (Table 3). The ocellated turkey (*Meleagris ocellata*) is indigenous to Petén (Anderson and Tzuc 2005: 29), although the domesticated Mexican turkey (*Melagris gallopavo*) also may have been present (Masson and Peraza Lope 2008: 173). Other potential matches such as quails are rarely identified in archaeological remains (see Masson and Peraza Lope 2008: Table 2). Turkey and quail were frequent ritual offerings (Evans and Webster 2013: 403): codices depict the decapitation of turkeys in ritual sacrifice (Tozzer and Allen 1910: 327) and in the Maya highlands turkey blood may be splashed onto altars (Wilson 1999: 72).

One point testing positive for chicken antisera was from Str. 747 (see sec. 4.1.1). The second specimen was relatively large, made of SMJ obsidian, and found south of the altar in Str. 721. This point might have been used to procure avians for a ritual or used in a ceremony where bird proteins or blood were present; the finding of an avian cranium in Str. 721 along its medial axis is consistent with decapitation ritual (Pugh et al. 2009: 206). Str. 719 was occupied through the end of the seventeenth century, and a positive for chicken could reflect the presence of the European domesticated chicken (*Gallus domesticus*).

5.1.3. *Deer*

Nixtun-Ch'ich' Mound ZZ1 was the only location that registered positives for deer, but CIEP does not distinguish between white-tailed (*Odocoileus*) and brocket (*Mazama*) genera. Deer hunting has a long history of ceremonialism among the Mayas (Anderson and Tzuc 2005: 72; Brown 2005; Pohl 1981). Almanacs in the Madrid Codex reveal deer hunting (often with an atlatl; von Nagy 1997) and deer trapping with seasonal and astronomical associations (Vail 1997; von Nagy 1997). Ethnographic information from Yucatán suggests ritualized sharing of meat following organized hunts, where the shooters took prime cuts including the head, leg, liver, stomach, and hide (Redfield and Rojas 1934: 48). Deer were often hunted with dogs, particularly around the dry season when deciduous foliage provides poor coverage (Schlesinger 2001: 179). Deer antlers were important tools for flint-knapping as punches or billets (Nations 1989: 454).

The two arrow points from Mound ZZ1 with positives for deer were both fairly large unnotched specimens made from SMJ obsidian (Meissner 2014: 354–359). Because this structure lies at the tip of a narrow, kilometer-long peninsula extending into Lake Petén Itzá, it is likely that hunting parties traveled west, south, and north to savannahs or deforested areas to find deer. Contemporary ethnographic accounts from Belize suggest that long-distance weaponry would be more effective in cleared areas, and that contemporary Mayas sometimes set fire to savannahs to attract deer for hunting (Graham 1994: 13-15).

5.1.4. *Dog*

Multiple points from Nixtun-Ch'ich' and Zacpetén tested positive for dog protein. Domesticated dogs (*Canis familiaris*) were common throughout the lowlands and were consumed as food as early as the Preclassic period (Clutton-Brock and Hammond 1994: 821). Dog antisera could also react with gray fox (*Urocyon cinereoargenteus guatemalae*) or possibly coyote (*Canis latrans goldmani*). Foxes appear on Classic period polychromes (Kerr 2014) and remains have been

found at several Petén sites including nearby Motul de San José (Emery and Brown 2008: 99). The range of coyotes likely did not extend into Petén, although they are found in Chiapas and the Guatemalan highlands, and coyotes are not typically depicted in Maya iconography.

At Zacpetén, dog protein was found on an El Chayal obsidian point in Str. 614 in ceremonial Group A, immediately south of mass grave Op. 1000 (see Duncan 2009: 342–344). Heavy impact damage was noted, suggesting it was discarded after breakage (Meissner 2014: 441). The presence of dog protein at a structure next to the mass grave may support associations between domesticated dogs, the Underworld, and death: dogs were often sacrificed to guide a deceased person's soul to the Underworld (Miller and Taube 1993: 80; White et al. 2001: 92). As mentioned previously, dog sacrifice using the bow-and-arrow was a cultural practice during the Contact period (Roys et al. 1940: 6), and dog hearts and blood were frequently used for New Year's renewals (Landa [in Tozzer] 1941: 114).

At Nixtun-Ch'ich' six points, all from the SMJ source, tested positive for dog (Meissner 2014: 59–62). Five came from Str. ZZ1/1 on the lower southern terrace of the mound, primarily in the eastern patio or near the doorway, and one was from nearby Str. ZZ1/2. Three points exhibited multiple antisera reactions with rabbit and rat in addition to dog. These multiple reactions suggest the points were used in hunting activities as opposed to rituals, and such positives could be attributed to the gray fox as opposed to domesticated dog.

5.1.5. *Human*

Two projectile points from Zacpetén had CIEP positives for human proteins. One was a side-notched point of Ixtepeque obsidian from residential Str. 664 (Fig. 4, right). This artifact had heavy impact damage extending across the blade into the haft, suggesting that it was used as a projectile against another human (versus ritual blood-letting from soft tissue or the possibility of blood contamination in flint-knapping; see Newman and Julig 1989: 128). This interpretation is bolstered by ethnohistorical accounts of armed inter-Maya combat in the region (see Jones 1989, 1998) and at Mayapán, arrow points were found embedded in skeletons (Serafin et al. 2014). Various chert and obsidian points were recovered around Str. 664 along with human teeth (Pugh 2009a: 178). Most points came from the open front room, whereas at other Zacpetén residences points tended to be in the back rooms (Pugh 2001: 459).

Fig. 4. Locations of obsidian points with human proteins. Left: Group A, Zacpetén. Right: Structure 664, Zacpetén (modified with permission from Pugh 2001:301, 464, Figs. 7-1, 9-2).

Another point with human protein residues was an unnotched El Chayal specimen from the floor of Str. 605, a west-facing oratorio in temple assemblage Group A (Pugh 2001: 529, 542). Manufactured from a small percussion flake, this wide but lightweight point's form suggests that it may have been hafted in a socketed shaft. The recovery of the point away from any midden materials and on a structure floor suggests that contamination is not plausible. Structure 605 had the most points ($n = 26$) of all structures in Group A.

5.1.6. Rabbit

Three points from the eastern patio of Str. ZZ1/1 at Nixtun-Ch'ich' tested positive for rabbit (Meissner 2014: 449). These points, both notched and unnotched, also tested positive for dog and rat antisera. Two species of rabbit are found in Petén, the forest cottontail *Sylvilagus brasiliensis* and the eastern cottontail *S. floridanus*. Rabbits were prized among the Maya as a food and fur source (Evans and Webster 2013: 257), and rabbit remains have been found in various Classic and Postclassic contexts throughout the lowlands (Emery and Brown 2008: 100; Masson and Peraza Lope 2008: 173–174). Remains of the jackrabbit (*Lepus*) are present but rare in archaeological contexts (Masson and Peraza Lope 2008: 173). Given the limits of its range, jackrabbit is the least likely match for a CIEP positive in the current study.

5.1.7. Rat

Four immunological positives for rat were detected in non-midden contexts at Nixtun-Ch'ich' Mound ZZ1: three in the eastern patio of Str. ZZ1/1, and the fourth on Mound ZZ1's upper terrace. Three of the points also had reactions with dog and rabbit antisera. These reactions are challenging to interpret, as nearly three dozen families of the order Rodentia are found in Petén. Species include porcupines, pacas, squirrels, mice, voles, gophers, and rats. Pacas (*Cuniculus*

paca or *tepiscuintle*) and agoutis (*Dasyprocta punctata*) are shy forest-dwellers with low profiles, and are common food sources (Anderson and Tzuc 2005: 92, 145; Masson and Peraza Lope 2008: 174; Schlesinger 2001: 150; see also Emery and Brown 2008: 100). Pocket gophers were also consumed (Evans and Webster 2013: 257), but were probably acquired by trapping instead of bow-and-arrow use (Hovey and Rissolo 1999). Young Lacandon boys were witnessed using small rodents in target practice (Blom and Duby 1955: 417), thus protein residues could also reflect activities used in skill development.

5.1.8. *Swine*

Positive reactions to swine (pig) antiserum were noted on two points from Zacpetén Strs. 602 and 664, probably representing two native Petén species: collared peccary (*Pecari tajacu*) or white-lipped peccary (*Tayassu pecari*) (Seeman et al. 2008: 2745). Peccary remains are found at varied Classic and Postclassic centers (Hamblin 1984; Masson and Peraza Lope 2008: 179; Shiratori et al. 2014), and evidence from Mayapán suggests that they were hunted rather than raised like whitetail deer or dogs (Masson and Peraza Lope 2008: 178–179). Peccaries were used during Maya *cuch* rituals, with contemporary dances substituting a pig’s head for peccary (Pohl 1981: 515, 517).

One heavier side-notched point of Ixtepeque obsidian was recovered from the interior of the Str. 602 temple in Group A. This group had both Late Postclassic and Contact period occupation (Pugh 2009b: 378), indicating that a reaction to European domesticated pig (*Sus domesticus*) is possible. Several cached chipped stone tools were found in the interior altar of Str. 602 and a radiocarbon date of AD cal. 1383–1441 (2 sigma) originated from burned incense in a small pit feature in the structure (Pugh 2001: 237, 241; Pugh and Rice 2009: 149–150). The recovery of this point in Zacpetén’s principal temple suggests its use in procuring animals for ceremonies, or as a ceremonial object used in rituals involving peccary remains.

In residential Group 664, a point tested positive for swine as well as cat and bear (coatimundi, see below). Unlike the point recovered from Str. 602, the context of this point lends support to a subsistence use, although its reaction with cat might also suggest it was used for multiple purposes.

5.2 *False positives or cross-reactions*

5.2.1. *Bovine*

Two points from Nixtun-Ch’ich’ tested positive for bovine antisera (non-native to the New World except for bison, *Bos primigenius*). Recent faunal analysis by Carolyn Freiwald (n.d.) has identified the remains of cow at the site, and may represent early Contact-period occupations or later associations with mission San Jerónimo. Spanish accounts place cattle in Petén by at least AD 1696, just prior to Itza conquest, perhaps arriving from Bacalar (Quintana Roo, Mexico) (Farriss 1984: 33; Jones 1998: 244).

One positive specimen from Nixtun-Ch’ich’ was an asymmetrically side-notched point from a large refuse deposit on the southern slope of Mound ZZ1, where colonial artifacts including “olive jars” (*botijas*), metal, and beads have been recovered. The other, from Str. DD2, is most likely a false positive or contaminated sample as it was recovered in the humus above a Classic or Terminal Classic ballcourt.

In addition, an obsidian flake from Zacpetén tested positive for bovine, suggesting some stone implements may have been used in processing or even ritual activity. A cow mandible found on an altar in Structure 719 showed signs of use wear or modification, illustrating the symbolic value given to cattle during the Contact period, when their remains were salient to the Mayas (Pugh 2009b: 381–382; Pugh et al. 2009: 195).

If bovine positives are indeed correct, it is possible that the bow-and-arrow was used in cattle raiding during the early Contact period, as documented throughout colonial Yucatán and Belize (Drew 1999: 404; Farris 1983: 270; Güémez Pineda 2002). It is unclear, however, if the animals were fired upon and their carcasses brought back to communities, or if the arrows were used in hunting rituals involving previously killed animals. The slaughter of large mammals was considered an act of bravery (Landa [in Tozzer] 1941: 203; Pugh 2009b: 382).

5.2.2. *Bear*

Immunological positives for “bear” on six points from Zacpetén are perplexing, as bears are not extant in the lowlands. The nearest range is that of the black bear (*Ursus americanus machetes*) in north-central Mexico. These results are thus likely due to an unknown cross-reaction (a possible distant genetic relative) or a false positive. Genetically similar lowland mammals include the white-nosed coatimundi (*Nasua narica*), a member of the raccoon family, and the kinkajou (*Potos flavus*), both of which share distant relations with bear in the infraorder Arctoidea and an evolutionary lineage revealed through DNA hybridization (Ostrander and Wayne 2005). Undiluted lots of antisera can occasionally cross-react: a lot of bovine antiserum, for example, was found to test positive for elk unless it was diluted to a 1 to 4 ratio (Newman et al. 1997: 1025). Thus, the “bear” positives at Zacpetén may represent procurement of coatimundi or kinkajous.

5.2.3. *Sheep*

A positive for sheep (or goat) proteins was found on a specimen from Zacpetén. Old World sheep (*Ovis aries*) were not widely adopted in the lowlands by either Spaniards or Mayas (Anderson and Tzuc 2005: 30), likely due to the challenges of the humid tropical environment (Farriss 1984: 31). Nevertheless, sheep were present in Yucatán and Belize during the time of Spanish contact (ibid.) and the Mayas incorporated large livestock remains, including sheep, into ceremonial areas and burials (Hamblin 1984: 142–143). Like sheep, goats (*Capra hircus*) were not widely raised in the lowlands and the threat of jaguar or coyote predation made them uneconomical (Anderson and Tzuc 2005: 30, 66; Schlesinger 2001: 162). To date, no sheep or goat remains have been identified in Petén faunal assemblages, raising suspicion about this particular CIEP result.

6. Discussion and Conclusions

Immunological testing of 108 Postclassic and Contact period obsidian arrow points in central Petén yielded 36 positives on 25 points from two sites: Zacpetén and Nixtun-Ch’ich’. This study provided new information regarding the use of the bow-and-arrow in the southern lowlands, including subsistence and ritual activities. For example, CIEP analysis of protein residues on the points revealed that a wide range of lowland fauna were procured using the bow-and-arrow,

including avian, feline, swine, canine, rabbit, rodent, and deer. Most of these except feline were probably subsistence animals and bones of most have been identified at these Petén sites by zooarchaeologists (Freiwald 2013, n.d.; Shiratori et al. 2014). Many points had multiple reactions, meaning they were recovered and reused in hunting other game.

CIEP analysis of these obsidian arrow points revealed their use in hunting birds, which contrasts with contemporary Lacandon practices of bird hunting using solely wooden tips. Game size and habitat may be factors, as larger ground birds may have been hunted with stone points due to the decreased chance of losing an arrow compared to hunting smaller birds living in the forest canopy. Thus, it is still possible that perishable wood-tipped points were used for the latter. This study did not reveal any strong correlations between targeted fauna and point morphology, although there is likely a tendency for the use of larger points for larger game. Because we lack a comparative sample of CIEP results from microcrystalline silicate points, however, it is difficult to know if obsidian points were considered more suitable for larger game (deer, peccary, jaguar, humans). Even small obsidian points may have been favored for large fauna due to their ability to create mortal wounds, as noted among the contemporary Lacandon (Nations 1989: 454).

Some of the indigenous fauna had ritual significance for the Mayas, particularly jaguar, deer, and certain avians. CIEP results also indicate that animals introduced by the Spaniards, particularly cattle, may have been procured with the bow-and-arrow. Some of these may have replaced indigenous fauna in ritual usage, where sacrificial blood or animal parts may have been used symbolically in conjunction with small projectile tips.

Most points submitted for CIEP analysis had negative responses, meaning they were either unused, or that any proteins once present on the points were too degraded to identify. Some reactions were questionable—either testing positive for Old World animals (sheep/goat) or animals not in the range of the Maya lowlands (bear). Such results could be considered false positives or cross-reactions with genetically-related species, although some reactions might actually be attributed to the early Contact period and the ritual use of animal elements.

Two positive reactions to human protein, both from Zacpetén, provide the first material evidence of arrows being used against other humans in Petén, and confirmation of many accounts of armed inter-Maya conflicts. However, these were from two different contexts, both ritual and residential. The point from Str. 605—an oratorio in a predominantly ceremonial area—demonstrates the importance of stone points in ritual contexts, possibly used in bloodletting. The specimen from residential Str. 664 may have been used in raiding activities or perhaps even organized attacks. Group 664 is located closer to the defensive works at Zacpetén, and individuals there may have participated in the protection of the site.

In sum, CIEP provides tentative insights into the usage of arrow points and the bow-and-arrow among the Postclassic and Contact period Mayas of Petén. The small points analyzed in this study came from varied residential and civic-ceremonial activity areas and illustrated that the presence of an arrow point may reflect not only subsistence/hunting or warfare but also ritual activity; moreover, a single point may indicate a combination of these uses. Context, as always, is critical in interpreting immunological results.

Acknowledgements

We would like to thank the two anonymous reviewers of this manuscript for their helpful comments and suggestions. Research was funded by a National Science Foundation dissertation improvement grant to Prudence Rice and Nathan Meissner (#1146372). Archaeological data

were gathered from NSF Grants to Rice and Timothy Pugh (#0917918, #1037927, and #0742295). Previous support for excavations at Nixtun-Ch'ich' was provided by the Heinz Foundation and the National Endowment for the Humanities. We thank the following individuals for their support: Timothy Pugh, Don Rice, Carolyn Freiwald, Kevin Schwarz, Joel Palka, Yuko Shiratori, and Evelyn Chan. CIEP was performed by Robert Yohe II and Carrie Stephens at the Laboratory of Archaeological Science at the University of California Bakersfield. Institutional support was provided by the Instituto de Antropología e Historia de Guatemala, and Licda. Rita Casas helped with obtaining permissions for exports.

Appendix A: Inline Supplementary Material

Commercial antisera used for this study were manufactured by Cappel Research (now MP Biomedicals) (n = 14), with small quantities from Lampire Biomedical (n = 2), and Cedarlane Laboratories (n = 1). Positive immunological reactions found by this study originated solely from antisera manufactured by Cappel Research/MP Biomedicals. In this study, prepared antisera are all polyclonal. Such antisera are prepared specifically for forensic applications, which includes the technique of affinity adsorption to purify samples at a molecular level in an effort to minimize cross-reactions. According to company information, antisera were “adjusted to a standard 60 mg/ml, dialyzed into 0.02M sodium phosphate, 0.14M sodium chloride, pH 7.3, supplemented with 0.05% sodium azide followed by filtration through 0.22µm filters and lyophilized” (Cappel Research Reagents n.d.: 9). Unfortunately, the exact species of each animal used to produce individual antisera is unknown despite direct requests with the manufacturers at MP Biomedicals. Such information is nevertheless important, and should be made available for researchers in future CIEP applications. Type numbers of each antiserum can be located from the original catalog:
<http://ziobio.com/ICN%20PDF/Immunobiologicals/Cappel%20Primary%20and%20Secondary%20Antibodies.pdf>

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