Evidence for Bow and Arrow Use in the Small Point Late Archaic of Southwestern Ontario

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This paper focuses on evaluating evidence for the use of the bow and arrow through analysis of stone projectile point assemblages of Late Archaic and Early Woodland age recovered from sites in southwestern Ontario (Figure 1). It had been assumed until fairly recently that the bow and arrow had a relatively late introduction appearing in the Eastern Woodlands around A.D. 700 when it replaced the previously used short javelin/dart thrown with the aid of a throwing stick or "ataltl" (e.g. Blitz 1988:131; Shott 1993). However, a number of studies have begun to question this and suggest that the bow and arrow arrived much earlier, during the Late Archaic, 3500 years ago or even earlier. Good examples of this trend are Bradbury's (1997) and Odell's (1988) studies of material from Midwestern Archaic sites. In the Great Lakes-St. Lawrence area, J. V. Wright (1994, 1999:620-622) argued that the arrow arrived with Meadowood points of his Initial Woodland at 2800 BP. Even earlier, in an unfortunately unpublished paper, the late Ian T. Kenyon (1980c), as always ahead of his time, argued that arrows were in use earlier as represented by the Terminal Archaic Crawford Knoll site points in southwestern Ontario at ca. 3500 BP, and perhaps even earlier as represented by Archaic Lamoka points (Ritchie 1971:29-30) best known from New York state. Kenyon's conclusion was based on some use of the then recently published work of David Hurst Thomas (1978) on definitive ethnographic or completely preserved archaeological specimens of darts and arrows, although he did not use Thomas' (1978) actual formulae to make the distinction, the nature of which we will discuss below.

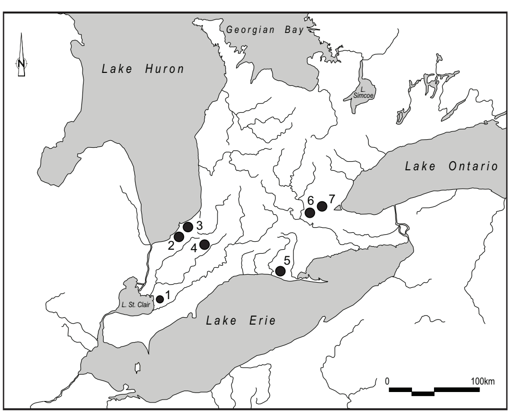


Figure 1. *Location of sites mentioned in the text. 1: Crawford Knoll; 2: Adder Orchard and George Davidson; 3: Parkhill; 4: Welke-Tonkonoh; 5: Bruce Boyd; 6: Innes; 7: Thistle Hill.*

Despite these musings, in the Great Lakes area few detailed studies have been done to evaluate the question of bow and arrow use. Moreover, no one has taken advantage of research elsewhere that has devised new and improved ways of distinguishing dart and arrow points in archaeological contexts. Hence, we report here on attempts to do the same through application of these techniques to a series of Late Archaic and Early Woodland assemblages from Ontario. Important to our discussions are a series of points recovered from the Terminal Archaic/Early Woodland Bruce Boyd cemetery near Long Point on Lake Erie excavated by Michael W. Spence (e.g. Spence et al. 1978; Spence and Fox 1986), so it is only fitting that we present our results in the special volume in his honour.

Our main goal initially was to evaluate Ian Kenyon's (1980c) suggestion that the points recovered from the Terminal Archaic Crawford Knoll site in Ontario, represented the use of the bow and arrow; thus, there is a bias in our samples towards Terminal Archaic sites. However, in order to give a time dimension to this work, and evaluate ideas about potential arrow use for other point forms, such as the arrow use suggested for

Meadowood points by J. V. Wright (1994), data on three kinds of assemblages, which likely represent a time series, were included. These three manifestations are the Broad Point Archaic of ca. 4000 to 3500 BP, the Small Point or Terminal Archaic of ca. 3500 to 2800 BP and the Early Woodland Meadowood Phase of ca. 2800 to 2300 BP.

The Broad Point Late Archaic is characterized by very large or "bulky " stemmed points that in southwesternmost Ontario can be placed largely into two, apparently time sequential, types: Adder Orchard and Genesee (Kenyon 1983; Figure 2). For this study, we relied mainly on published data from three Broad Point sites near Lake Huron analyzed by Jacqueline Fisher (1997) and Ian Kenyon (1980a, 1980b): the Adder Orchard site itself, as well as the Genesee components from the George Davidson and Parkhill sites.

The Small Point Archaic is characterized by a whole series of named notched to expanding stemmed point types called Crawford Knoll, Innes, Ace-of-Spades and Hind (Ellis et al. 1990, 2009; Kenyon 1989; Lovis and Robertson 1989). These items markedly contrast in size with the much larger forms in preceding Broad Point assemblages. Assuming a time series, as Ian Kenyon (in Ellis et al. 1990:106) argued, such a marked and rapid change in point styles from Broadpoint suggests that something profound affected these changes in points, perhaps a change in weapon systems.

We were able to collect information on several collections of Smallpoints (Figure 1). These collections included first, Crawford Knoll. Situated on a small knoll near Lake St. Clair in what was an extensive marshy area at the time of the occupation, this site was partially excavated by Ian Kenyon in 1979 (Kenyon 1980c; Kenyon and Snarey 2002). These excavations revealed an occupation area with pit features on top of the knoll and an extensive midden area with superb bone preservation on the side of the knoll extending into what would have been the old marsh edge. The site has a single radiocarbon date of 3400 BP on bone from the midden and yielded a good series of the tiny notched and often serrated Crawford Knoll type points (Figure 3), which Kenyon (1980c) convinced tipped arrows. Kenyon (1980c) noted that the Crawford Knoll site points closely resemble certain midwestern Terminal Archaic types, notably the Merom Expanding Stemmed and Trimble Side-Notched points of the Riverton Archaic of Illinois (Winters 1968), which date to exactly the same time as Crawford Knoll and are the types that Bradbury (1997) argued often tipped arrows.

A second site collection was derived from the Innes site near Brantford associated with two radiocarbon dates between ca. 3500 and 2800 BP (Lennox 1986). Most of the points (Figure 4a-g) are slightly larger than those from Crawford

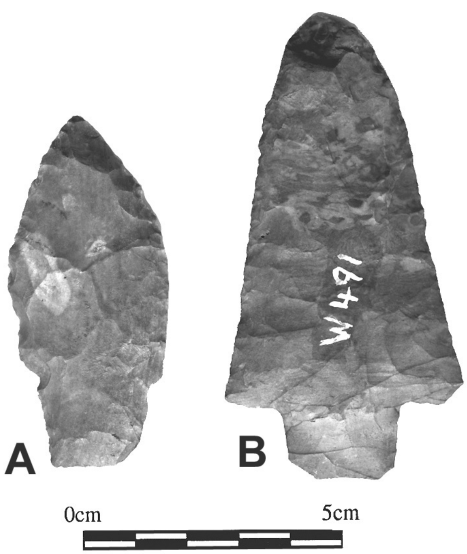


Figure 2. *Broad Point types. A: Adder Orchard; B: Genesee; University of Western Ontario collections.*

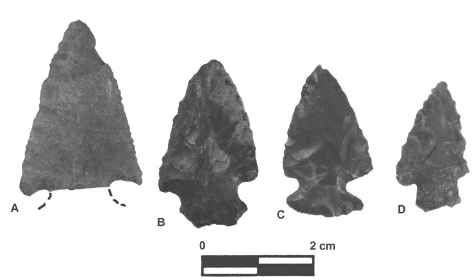


Figure 3. *Crawford Knoll points, Crawford Knoll site.*

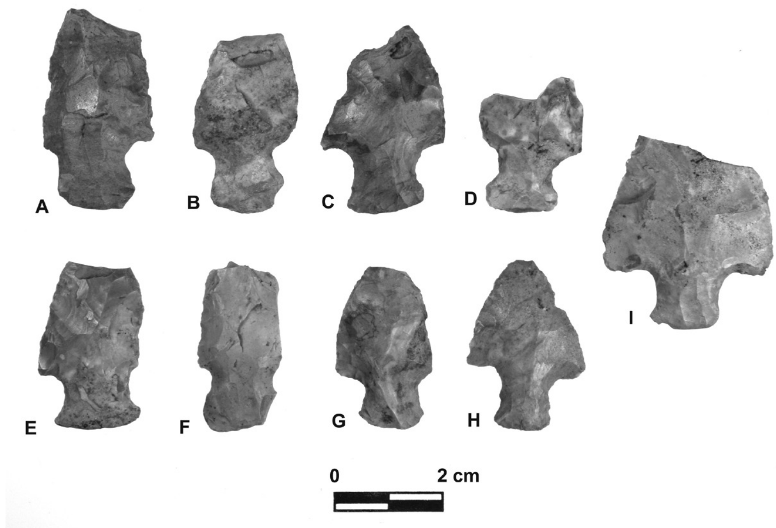


Figure 4. *Innes site points. A-G: Innes type; H-I: Ace-of-Spades type.*

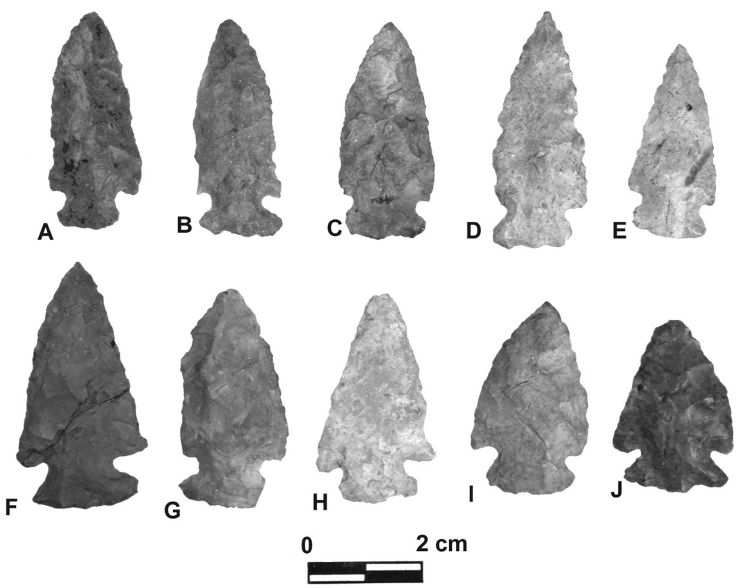


Figure 5. *Crawford Knoll type points, Bruce Boyd site, Feature #9. These examples were selected to show the range of variation in size and fore-section shape.*

Knoll, and are of an expanding stemmed form that have been called Innes points; there are however, four larger, especially broader, points that many would assign to the Ace-of-Spades type and that some have suggested may be specialized knives or hand-launched spears, as opposed to dart, tips (e.g. Figure 4h-i).

A third site collection, and one alluded to earlier, included the several caches associated with burials at the Bruce Boyd Site near Lake Erie, investigated by Michael Spence (Spence et al. 1978; see Figure 5). Such burials have been referred to in the literature as the "Haldimand Complex " (Spence and Fox 1986:8-11) and although not directly dated, the points are clear examples of Crawford Knoll type points.

A fourth collection included several points recovered from Area D at the Parkhill site near modern Lake Huron excavated under the direction of the late William B. Roosa of the

University of Waterloo (Ellis 1998). A feature associated with that occupation containing a point basal fragment was radiocarbon dated to ca. 3500 BP. The points are quite tiny expanding stemmed forms (Figure 6), which again can be assigned to the Crawford Knoll or even Merom Expanding Stemmed type.

The final collection directly examined was that from the Welke-Tonkonoh site west of London excavated by Ellis in 1980 and described in detail by Muller (1989). These items (Figure 7) all came from Area A at that site and derive partially from a buried subsoil deposit preserved under an old fence-line. They consist of several somewhat larger, well-made, corner-notched points that generally fit into the Hind type (these are the "large " Smallpoints and along with "narrow " Broadpoints make the Late Archaic home of the main point oxymorons of Ontario archaeology); they may be assigned to the Hind point type but they are much smaller than examples of that type found in Glacial Kame burial sites such as the Hind site itself (e.g. Donaldson and Wortner 1995: Figures 22a-d, 28d-e); one suspects some of the burial items, however, are specially made as grave inclusions and hence, their larger size (Kenyon 1989:17). There are no radiocarbon dates on this assemblage but we guess it dates later in the Small Point Archaic or closer to 2800 BP.

In addition to these assemblages, we were able to incorporate published data on the 3500 BP Thistle Hill site near Hamilton, Ontario excavated by Phil Woodley (1990). The points from this site are assigned to the Innes style or type. We also included some Hind points directly

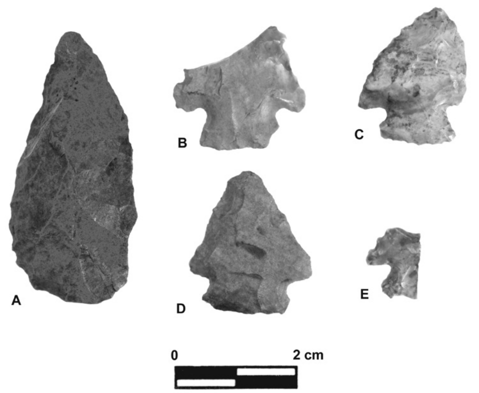


Figure 6. *Crawford Knoll points and preform, Parkhill site Area D. A: typical tear-drop shaped preform; B-E: points. E was recovered in situ in a feature dated 3400 ± 210 BP (I-8866).*

measured from Bruce Boyd but the samples are so small as to render them of little use here.

The final point form considered in this study was the Meadowood point assignable, we believe, to the Early Woodland, of ca. 2800 to 2300 BP or the immediate post-Small Point period and in fact, there are many similarities between Meadowood and later dating Small Point assemblages, such as the fact both produced bar-type birdstones, suggesting some degree of continuity (Ellis and Spence 1997; Spence and Fox 1986). Two samples of Meadowood points were used. One derives from the Bruce Boyd cemetery grave lots (Spence et al. 1978). The Meadowood component at Bruce Boyd has been radiocarbon dated to ca. 2500 BP. The second sample is a surface collection predominantly from what is called the Meadowood " area at the Welke-Tonkonoh site, a collection amassed mainly by Brian Deller (Ellis 1999; Ellis et al.

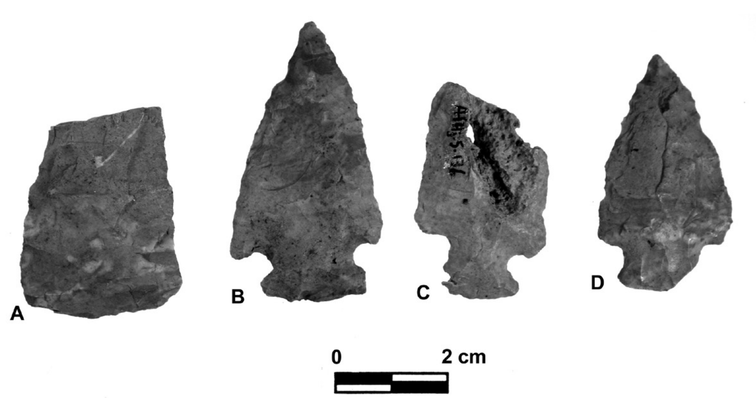
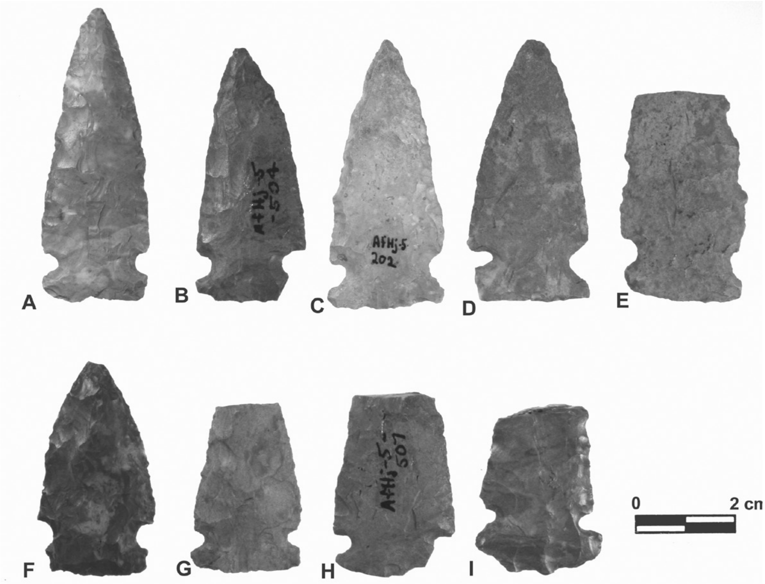


Figure 7. *Cache blade (A) and Hind points (B-D), Area A-West, Welke-Tonkonoh site.*

Figure 8. *Meadowood points, Welke-Tonkonoh site.*



1988). Welke-Tonkonoh is an exceptionally large assemblage, the largest reported we believe from any one Meadowood occupation site in Ontario (e.g. Figure 8).

Recognizing Darts and Arrows

Overall, these sites provided a total of 267 points. However, due to the fragmentary nature of some specimens only a maximum of 198 could be classified. We stress "maximum " since the measurements required in some kinds of analyses were lacking on some incomplete items so our totals vary from analysis to analysis.

Considering that there are obvious differences in how the throwing stick and bow were used, it would make sense that there would be corresponding different design criteria used in their manufacture and therefore, possibly, a means of distinguishing archaeological dart points used with the spearthrower from arrow points. Any familiarity with ethnographic and archaeological bows, arrows and spearthrower darts with intact shafts suggests a main distinguishing criterion for arrows and darts is relative size. The problem has been to quantify the size difference in a way that would allow us to distinguish the choice of weaponry. Criteria have been proposed since the 1930s to evaluate ideas about projectile weapon change and many of these and their potential implications for the assemblages examined here were examined in a broader study by Snarey (2000). However, for the sake of brevity, and also because we believe they are more accurate, we focus here on criteria developed within the last 30 years and refined in the last 10 years. These criteria include the various formulae developed by investigators such as David Hurst Thomas (1978), Andrew Bradbury (1997) and Michael Shott (1997), which use discriminant functions to distinguish spear and arrow points. To develop these discriminant functions, these investigators used ethnographic and archaeological data from known dart and arrow specimens based on samples from all over North America. In discriminant function analysis measurements for each point are substituted into two formulae, one for arrows, and one for darts. We show Andrew Bradbury's (1997) formulae here as an example:

$$\text{Arrow}=(0.632\text{xWidth})+(0.5082722\text{xNeck Width})-7.86771$$
$$\text{Dart}=(1.420838\text{xWidth})+(0.05398166\text{xNeck Width})-17.31622$$

Of the two computed numbers, the formula that results in the highest number determines how each point will be classified (e.g. if the number is higher for the dart formula it is a dart; if it is for the arrow formula, it is an arrow). The closer the two numbers are to each other, the more likely the classification is wrong. Although Thomas (1978), Bradbury (1997) and Shott (1997) all derived such functions, they differ in several respects. One area of difference is, of course, the exact samples they used; since there are a limited number of intact arrows and darts available there is some overlap in the samples used but they do differ in scope. The original sample data was produced by David Hurst Thomas (1978) and it had some shortcomings, notably in that only 10 darts were available for inclusion. Bradbury (1997) developed functions that use different measures but he essentially used the same data set published by Thomas (1978) so that data could be seen as having the same flaw (e.g. small samples and particularly for darts). Shott (1997) used Thomas' (1978) sample, but he was also able to augment it by the inclusion of several additional specimens and raise the total of darts to 39 or almost four times Thomas' (1978) sample size. One presumes that larger samples are more representative and therefore, that Shott's functions would be the most reliable.

The various functions also differ in what variables are needed (Table 1). For example, Thomas' (1978) formula requires one to have measurements of length, width, thickness, and neck width for each point. Bradbury (1997), however, used mainly total width and neck width alone; he argued, and this is an important point, that length is too affected by resharpening and reworking to be useful and is rarely preserved on many points, severely limiting sample sizes. Shott (1997:94) also recognized that variables such as length could be affected by resharpening and therefore, developed several functions using different variables; what he called four variable, three variable, etc. classification functions. As summarized on Table 1, the four variable used length, shoulder width, thickness and neck width; the three variable eliminated length as that is often not preserved on archaeological specimens; the two variable eliminated neck width because it seemed to be synonymous with shoulder width and also could not be recorded on unnotched point varieties; and the one variable used only shoulder width. Shott (1997) found shoulder width to be the best predictor of any single measurement and noted that as a rule of thumb, most points over 20 mm at the shoulder are darts whereas most below are arrows.

Table 1. *Variables used in different discriminant functions.*

Equation	Variables Used
Thomas, 1978	Length, Maximum Width, Neck Width, Thickness
Bradbury, 1997	Maximum Width, Neck Width
Shott, 1997	Four Variable: Length, Shoulder Width, Neck Width, Thickness
Shott, 1997	Three Variable: Shoulder Width, Neck Width, Thickness
Shott, 1997	Two Variable: Shoulder Width, Thickness

On Table 2 we show how successful the various functions were in actually assigning the samples of known darts and arrows used to each category. Taking these at face value, arrows are almost always classified correctly, 87.1% or more. Darts are more often misclassified suggesting of course that it is very possible to use a small dart on a larger haft but that the smaller hafts of arrows often require smaller points. Nonetheless, in excess of 70%, and in most cases in excess of 80% of the darts were classified correctly. The fact there are some mis-classifications of course means that one must look at overall patterns by site or point type to see if there are dominant themes;

Table 2. *Classification of known arrows and darts by different function.**

Discriminant Function	Arrows Correctly Classified	Darts Correctly Classified	Overall Correctly Classified
Thomas	87.1%	70.0%	85.9%
Bradbury	89.4%	80.0%	88.7%
Shott 4V	89.4%	76.9%	86.5%
Shott 3V	90.8%	84.6%	89.4%
Shott 2V	89.2%	84.6%	88.2%
Shott 1V	90.8%	84.6%	89.4%

*4V: four value; 3V: three value; 2V: two value; 1V:one value.

one does not expect 100% assigned to one or the other. Some have used Bradbury's (1997) functions as they require fewer variables and thus allow classification of more fragmentary items (Erwin et al. 2005:56). However, with these results as a guide (Table 2), as a whole, the Shott (1997) three variable and one variable functions seem the most accurate and this reinforces the idea that his functions, in general, are more reliable because they are based on larger samples. In our view they are far superior. We did think it of interest to compare all the functions in our search for overall patterns in these data but we believe the Shott (1997) functions are much more preferable when it comes to splitting hairs in interpretations.

Results

Turning to the actual analyses, Figure 9 shows the percentage of arrows by site arranged in roughly chronological order from left (Broad Point) to right (Meadowood) and Table 3 shows the assignments to arrows by point type. These data emphasize the substantial increase in the percentage of points classified as arrows at the start of the Small Point era, while perhaps not unexpectedly, virtually no Broadpoints were classified as arrows. It is no surprise that one can safely conclude that Broadpoints were not arrow tips. Even the few Broadpoints that were classed as arrows (Tables 3 and 4) actually show signs of being reworked, something that discriminant function analysis really cannot account for or at least, it is unclear how it is affecting the ethnographic and preserved archaeological samples used to derive the functions. Most of the preserved known archaeological darts are from dry caves and it is very plausible they are caches or samples with more unreworked or less exhausted points. The ethnographic specimens may also be dominated by larger, more pristine, examples. Therefore, one might expect a bias towards larger items and this would strengthen the idea that the few Broadpoint "arrows " are spurious. Of course, it may be that Broadpoints were not weapon tips at all. In the Southeast it has been argued they are simply knives (e.g. Sassaman 2006:121-127). However, unlike the Southeast, Ontario Broadpoints occur with tip impact fractures indicating at least some tipped projectiles (e.g. Fisher 1987). We need much more study of this question. They could also be hand-launched spear tips associated with what are otherwise Small Point occupations (e.g. Stothers 1983; Stothers et al. 2001:238). However, given that Broadpoints are found much beyond the Great Lakes in areas such as New England where there is no evidence of any Smallpoints whatsoever, that they predate the earliest evidence of Smallpoint use by greater

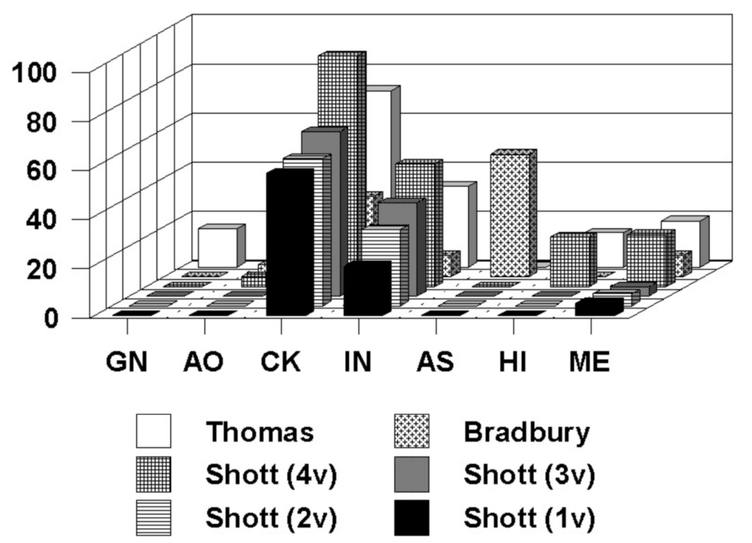


Figure 9. *Percentages of arrows by point type. Types are arranged largely by relative age from left (earliest) to right (latest). GN: Genesee; AO: Adder Orchard; CK: Crawford Knoll; IN: Innes; AS: Ace of Spades; HI: Hind; ME: Meadowood.*

Table 3. *Classification of points as arrows by type.*

Function	Adder Orchard	Genesee	Crawford Knoll	Innes	Ace-of-Spades	Hind	Meadowood
Thomas	2/23 8.7%)	1/9 (11.1%)	33/46 (71.7%)	2/5 (40.0%)	0/2 (0.0%)	1/7 (14.3%)	6/32 (18.8%)
Bradbury	2/33 (6.1%)	0/15 (0.0%)	18/54 (33.3%)	2/20 (10.0%)	0/2 (0.0%)	0/7 (0.0%)	5/56 (8.9%)
Shott 4v	1/22 (4.5%)	0/9 (0.0%)	45/48 (93.8%)	4/7 (57.1%)	0/0 (0.0%)	1/5 (20.0%)	7/33 (21.2%)
Shott 3v	0/33 (0.0%)	0/15 (0.0%)	34/51 (66.7%)	6/17 (35.3%)	0/2 (0.0%)	0/7 (0.0%)	2/53 (3.8%)
Shott 2v	0/34 (0.0%)	0/15 (0.0%)	31/52 (59.6%)	5/17 (29.4%)	0/2 (0.0%)	0/7 (0.0%)	3/56 (5.6%)
Shott 1v	0/35 (0.0%)	0/15 (0.0%)	32/55 (58.2%)	4/21 (19.1%)	0/4 (0.0%)	0/7 (0.0%)	3/61 (4.9%)

Table 4. *Classification of Broadpoints as arrows by site.*

Function	Adder Orchard	George Davidson Genesee	Parkhill Genesee
Thomas	2/23 (8.7%)	1/6 (16.7%)	0/3 (0.0%)
Bradbury	2/33 (6.1%)	0/8 (0.0%)	0/7 (0.0%)
Shott 4v	1/22 (4.5%)	0/6 (0.0%)	0/3 (0.0%)
Shott 3v	0/33 (0.0%)	0/8 (0.0%)	0/7 (0.0%)
Shott 2v	0/34 (0.0%)	0/8 (0.0%)	0/7 (0.0%)
Shott 1v	0/35 (0.0%)	0/8 (0.0%)	0/7 (0.0%)

than 500 radiocarbon years, and suggestions of different burial practices from Small Point associated peoples, we believe this is highly unlikely (Ellis et al. 2009; Snarey 2000:26-28).

Given a time sequence, a second point of note about the general pattern (Figure 9) is of course, that much higher percentages of Smallpoints are classified as arrows. Focussing in on Crawford Knoll type points, most of these points are classified as arrows (Table 3) although the percentage varies from site to site (Table 5) due to some variation in the samples (see Table 6). In the overall sample, and using Thomas' (1978) original function, from 62 to 100% per site are arrow tips (Table 5). Shott's (1997) various formulae result in 55 to 100% being classified as arrows. Surprisingly, given that Bradbury (1997) argued that the very similar points to Crawford Knoll from the Illinois River valley, such as Trimble Side-Notched, included many items that were arrow tips, few were classified as arrows using his function; we note the percentages of arrows were quite low even in his sample using his function for these general kinds of points but not as low as the totals reported here. We have already discussed the fact that Shott's (1997) functions overall are probably most reliable, and especially the 3-value and 1-value functions, as they are based on a much more comprehensive sample. On this basis, since 58-67% of the overall sample are classified as arrows using those functions, this evidence seems very supportive of arrow use.

Turning to individual site assemblages (Table 5), using Shott's (1997) functions 70 to 100% of the Crawford Knoll site points are classified as arrows, and the probably most reliable 3-value and 1-value functions result in arrow assignments ranging from 70-78%. At face-value, these totals seem enough to suggest most were points used on arrows as had been originally suggested by Ian Kenyon (1980c). Even though most are classified as arrows, the other sites, Parkhill and Bruce Boyd, are more ambiguous in the sense that lesser percentages (<67% for the 3-value or less functions) receive arrow assignments. It is possible that the Crawford Knoll site totals are inflated because, as noted above, the samples used to actually derive the functions may be biased towards larger, more pristine forms that were lost or cached rather than discarded upon exhaustion. If Crawford Knoll is more of an exhausted assemblage, one would expect reworking to reduce size, especially length, and this would result in more items classified as arrows, thus inflating the totals.

We did not observe any suggestion of extensive reworking in the Crawford Knoll assemblage. Yet, since length would be most affected given the somewhat elongated shape of the points, it is interesting that only functions that include length, namely Thomas' (1978) and Shott's (1997) 4-value, actually assign more Crawford Knoll site points to the arrow category. This result may indicate that reworking is reducing length and inflating the assignments to the arrow

Table 5. *Classification of Crawford Knoll points as arrows by site.*

Function	Crawford Knoll	Parkhill	Bruce Boyd
Thomas	5/6 (83.3%)	6/6 (100.0%)	22/34 (62.3%)
Bradbury	3/9 (33.3%)	2/7 (28.6%)	13/38 (34.2%)
Shott 4v	6/6 (100.0%)	6/6 (100.0%)	33/36 (91.7%)
Shott 3v	7/9 (77.8%)	4/7 (57.2%)	23/35 (65.7%)
Shott 2v	7/10 (70.0%)	4/7 (57.2%)	20/35 (57.2%)
Shott 1v	7/10 (70.0%)	4/7 (57.2%)	21/38 (55.3%)

Table 6. *Variables for Crawford Knoll type Points.**

Variable	Crawford Knoll	Parkhill	Bruce Boyd	Total Sample
Weight	N=7; R=1.3-4.2 X=2.779; SD=1.0715	N=6; R=1.2-4.1 X=2.070 SD=5.4113	N=34; R=1.9-5.5 X=3.260 SD=0.9058	N=47; R=1.2-5.5 X=3.036 SD=1.0119
Length	N=6; R=24.0-37.8 X=31.183 SD=5.4113	N=6; R=22.4-40.1 X=26.217 SD=6.8321	N=34; R=24.7-45.5 X=34.709 SD=5.4556	N=46; R=22.4-44.5 X=33.141 SD=6.2472
Fore-section Length	N=7; R=17.8-30.5 X=24.400 SD=5.1218	N=6; R=15.4-34.6 X=19.633 SD=7.3837	N=34; R=19.2-37.4 X=27.438 SD=4.5174	N=47; R=15.4-37.4 X=25.989 SD=5.5850
Maximum				
Width	N=9; R=14.0-20.5 X=17.800 SD=2.0591	N=7; R=15.9-22.0 X=18.829 SD=2.1368	N=37; R=15.0-26.6 X=19.078 SD=2.5125	N=53; R=14.0-26.6 X=18.828 SD=2.4036
Shoulder				
Width	N=10; R=14-22.4 X=18.260 SD=2.4378	N=7; R=15.2-22.0 X=18.736 SD=2.2990	N=38; R=14.3-26.6 X=18.961 SD=2.5949	N=55; R=14.0-26.6 X=18.805 SD=2.5028
Neck Width	N=11; R=7.6-11.2 X=9.491 SD=1.1353	N=7; R=10.0-13.0 X=11.000 SD=1.0755	N=38; R=8.0-13.8 X=10.376 SD=1.2556	N=56; R=7.6-13.8 X=10.280 SD=1.2720
Basal Width	N=11; R=8.8-15.7 X=12.600 SD=1.8714	N=7; R=11.9-16.0 X=13.443 SD=1.4853	N=34; R=10.8-18.9 X=14.453 SD=1.8236	N=52; R=8.8-18.9 X=13.925 SD=1.9221
Stem Length	N=11; R=3.0-4.8 X=3.818 SD=0.5600	N=7; R=3.4-4.5 X=3.914 SD=0.3891	N=35; R=2.9-6.0 X=4.306 SD=0.7821	N=53; R=2.9-6.0 X=4.153 SD=0.7245
Thickness	N=10; R=4.0-7.1 X=5.600 SD=1.1215	N=7; R=3.9-6.8 X=5.186 SD=0.9173	N=33; R=4.2-6.8 X=5.397 SD=0.7235	N=50; R=3.9-7.1 X=5.408 SD=0.8310

*N = # of observations; R = Range; X = mean; SD = Standard Deviation.

category. On the other hand, the Bruce Boyd site sample seems to be a useful comparison here since the items are from grave lots probably less affected by resharpening and perhaps, more comparable to the samples of known weapon systems used to derive the functions. They may not be totally pristine, and in fact, two items from the small five point cache associated with Feature 20 at Bruce Boyd, a child burial, are incomplete. When length is not used, a lower percentage, 55 to 65%, is classified as arrows. However, when length is included in the Shott (1997) 4-value functions, 92% of the items at Bruce Boyd are classified as arrows. If these caches are less affected by reworking, and the inclusion of length still actually increases the number assigned to arrows, we believe resharpening is not that much of a factor in inflating the arrow totals for the points at Bruce Boyd. It is possible to test the idea that some assemblages like Bruce Boyd may be less reworked than others. On the assumption that point foresection length, overall length and perhaps overall width and shoulder width might be reduced as a point gets more exhausted, we did several statistical comparisons. Specifically, an Anova was run comparing the three site samples of concern here and there are significant differences in the fore-section length (F=6.609; df:=46; p=.003) and overall length (F=6.223; df=46; p=.004), but there are no significant differences amongst the width measurements. A Tukey HSD Post-hoc test reveals that real length differences are between Parkhill and Bruce Boyd

Table 7. *Classification of Innes/Ace of Spades points as arrows by site.*

Function	Innes (incl. Ace of Spades)	Innes (excl. Ace of Spades)	Thistle Hille
Thomas	1/4 (25%)	1/3 (33.3%)	1/3 (33.3%)
Bradbury	3/16 (18.8%)	3/12 (25.0%)	0/6 (0.0%)
Shott 4v	3/4 (75.0%)	3/3 (100%)	1/3 (33.3%)
Shott 3v	5/12 (41.7%)	5/11(45.5%)	1/5 (20%)
Shott 2v	5/12 (41.7%)	5/11 (45.5%)	0/5 (0.0%)
Shott 1v	4/16 (25.0%)	4/12 (33.3%)	0/5 (0.0%)

Table 8. *Classification of Meadowood points as arrows by site.*

Function	Bruce Boyd	Welke-Tonkonoh
Thomas	4/18 (22.2%)	2/14 (14.3%)
Bradbury	2/24 (8.3%)	3/32 (9.4%)
Shott 4v	6/19 (31.6%)	1/14 (7.1%)
Shott 3v	2/21 (9.5%)	0/32 (0.0%)
Shott 2v	3/21 (14.3%)	0/35 (0.0%)
Shott 1v	3/26 (11.5%)	0/35 (0.0%)

(fore-section length, p=.004; length, p=.003) and that the Bruce Boyd and Crawford Knoll site samples are not significantly different in terms of fore-section or overall length. These results, and specifically the lack of any significant differences between the Crawford Knoll assemblage and the caches from Bruce Boyd, also suggest that the high percentage of points classified as arrows at Crawford Knoll is not due to reworking. If reworking is playing a role it may be in over-assigning points from the Parkhill site assemblage to the arrow category since they are significantly shorter than the items from Bruce Boyd. It is also notable that the Crawford Knoll site points do not differ significantly in length from the Parkhill site points and really they are intermediate in terms of length measurements between Parkhill and Bruce Boyd. This does suggest their size may have been affected by some reworking but not nearly to the extent of those at Parkhill. Moving on, some Small Point types, which actually seem to postdate Crawford Knoll forms, such as Innes and Thistle Hill, are classified as arrows but the percentage is much lowered in most functions (<57.1%; Figure 9; Table 3) even if one excludes forms that would be classified as Ace-of-Spades, which some have argued may be functionally different (see Table 7). On even later forms, such as Hind and Meadowood, there is an even smaller percentage that are classified as arrows (<21.2%; Figure 9; Tables 3, 8) and at face value, there is little or no basis to use the discriminant functions as evidence of arrow use. Percentages are so low for Meadowood that one could argue for no arrow use at all. This conclusion is the direct opposite of that of J. V. Wright (1994:60-62) who, using thinness of haft elements that can be under 5 mm on Meadowood points, and measures of known arrow shaft end diameters, argued Meadowood points were thin enough to tip arrows. However, Shott (1997:94-95) found thickness, albeit overall thickness, was not as useful a discriminating variable as shoulder width. In fact, if one looks at known darts, something that Wright (1994) did not consider, there are many known examples that had overall thicknesses under 5 mm (21/39 or 54%; see Shott 1997: Table 1; Thomas 1978: Table 10) and by extension, since haft ends are often thinner, a higher point percentage would have had haft elements under that size. In short, a thin and sharp point is probably just as useful on a dart as it is on an arrow and thickness is not that useful to discriminate the different kinds of weapon tips; while an arrow *need be* thin due to haft size, a dart *can be* too.

Discussion

A simple interpretation of the above data would be that most Crawford Knoll points were used as arrow tips, while the point forms pre-dating and post-dating those points were little used (later dating Smallpoints and Meadowood) or used not at all (earlier Broadpoints) for that purpose. While it makes sense that the shift from Broadpoints to Smallpoints does represent a switch from predominantly dart (or spear) to arrow use, the subsequent reversion to almost or actual total dart use in the later assemblages, especially Meadowood, seems somewhat strange to us. Indeed, these trends lead one to question whether even the earlier forms like Crawford

Knoll were arrow tips and to a suggestion that such readings may be false positives. Crawford Knoll points as a whole could be like the very small, occasional, definitive darts reported from sites such as White Dog Cave, Arizona (Guernsey and Kidder 1921). As noted above, there is a suggestion that darts can be smaller and hence, are more often misclassified, but arrows are more often required to be so and more easily classified as such. We note as well that among the known dart samples virtually none are under about 14 mm wide whereas the reported stone arrowpoints are often under that measure (75/132 or 57%). In this regard it is notable that none of the Crawford Knoll points in our sample are under 14 mm wide (Table 6), perhaps suggesting none are really arrow tips.

While the above data might suggest Crawford Knoll style points are not arrows, there are some other data that suggest their use as arrow tips. First, some of these points are very tiny, with many having neck widths under 10 mm (19/56 or 34.9%) indicating use of very small diameter shafts. It is difficult to believe that these points tipped darts (see especially Figure 3d and Ellis et al. 1990: Figure 4.24m), particularly since amongst the reported definitive darts almost none are known under 10 mm (2/39 or 5.12%; Shott 1997: Table 1; Thomas 1978: Table 3) and since reported post-contact arrow shaft diameters tend to cluster strongly under 10 mm (Wright 1994: Figure 4). We believe that neck width would be more crucial in relating to, or being more equal in size to, haft diameters. One needs to place and keep the point centered at the shaft end to maintain the arrow's or any projectile tip's balance and if the neck width was much narrower than the shaft then the point could easily slip from side to side and be off-centre. "Longitudinal symmetry, " or proper alignment of the point tip and haft, is essential for projectile use (Fischer 1989:38).

Second, earlier Broad Point assemblages elsewhere include definitive bannerstones (Claflin 1931; Cook 1976: Table 10; Dincauze 1972) and there are suggestions of such an association in Ontario as well (Ellis et al. 1990:104). Burial data elsewhere indicate bannerstones are most definitely atlaltl weights (see, for example, Cross 1999; Webb 1946; Webb and Hagg 1939:50, 55). In contrast, the Small Point Archaic represents an era in which those distinctive items disappear completely never to return. The disappearance of bannerstones at the same time as the massive changes in point size, are probably not simply due to coincidence.

Third, Shott's (1997) discriminant functions do not assign all Crawford Knoll points to the arrow category. Most, and especially the most reliable 3-value and 1-value functions, indicate 30-50% of the assemblages are best classified as dart tips. The interpretation one could make here is that most assemblages include a mixture of points used for both purposes and that, rather than the bow and arrow completely replacing the ataltl, both weapons continued to be used regularly alongside one another for some time. In fact, several investigators have made that argument although they may use more than simply discriminant functions to reach that conclusion (see below and Chatters et al. 1995; Nassaney and Pyle 1999; Shott 1996; Snarey 2000). If the Crawford Knoll point assemblages have a mixture of dart and arrow tips this could account for the variable percentage of assignments to the arrow category in some analyses. That being the case, and if dart points produced were slightly larger and arrow points smaller, one might actually find a bimodal distribution in the Crawford Knoll assemblages or at least, those with sizeable samples, provided the amount of use of each kind of weapon in a given assemblage was enough to show this bimodality. As well, one might expect that this bimodal distribution would be most likely to occur in the assemblages where lesser amounts of the overall samples are classified as arrows. For example, using Shott's (1997) functions substantially more of the Crawford Knoll points are classified as arrows by percentage than those at Bruce Boyd (Table 5), suggesting an emphasis more on arrows at the former versus the latter and that if both darts and arrows are used we would be more likely to see evidence of this at Bruce Boyd.

Shott (1997) suggested that shoulder width was the best single discriminator of dart and arrow tips. Interestingly, there is no indication of a bimodal distribution in the Parkhill site assemblage, and although there may be a slight skew towards the larger end of the overall distribution, such a break is not clearly evident at Crawford Knoll (Figure 10a), perhaps due to a small sample size. However, skewing and suggestions of a bimodal distribution are more strongly indicated in the Bruce Boyd sample, which: 1) has the least number of points assigned to the arrow category of all the samples; 2) provides the largest available series of points; and 3), as previous discussions suggested, are less affected by reworking or resharpening (Figure 10b). In fact, this distribution is even evident in the individual cache assemblages at Bruce Boyd where several points occur: Feature 9 (Figure 10c) and Feature 20 (Figure 10d). For illustrative purposes we show the actual points from Feature 20 separated into the two clear size categories (Figure 13; two are incomplete as noted earlier) and even in the larger Feature 9 assemblage it is possible to argue for two kinds of points, one form of which is narrower and more often side-notched with more parallel-sided fore-sections (e.g. Figure 5, upper row) and one of which is wider and more corner-notched with a more equilateral triangle shaped fore-section (e.g. Figure 5, lower row). Comparable variability probably also exists at the Crawford Knoll site although the latter form is represented mainly by incomplete forms (e.g. Figure 3a). The Bruce Boyd caches are actually ideal laboratories to look for these contrasts because they minimize not only variation due to reworking or resharpening but also, as short-term events, they minimize temporal variation/drift that could obscure modal patterning. These caches may also minimize idiosyncratic variation and are more likely to have a balance in frequencies of darts versus arrows on the assumption that they represent the composition of overall weapon tool kits. In sum, they are the cleanest context for controlling for and removing "noise " that could obscure such patterning and where bimodal trends would not be as masked by simple functional emphases at particular sites. Of even more interest, and certainly very consistent with bow and arrow and dart use, the two consistent modes

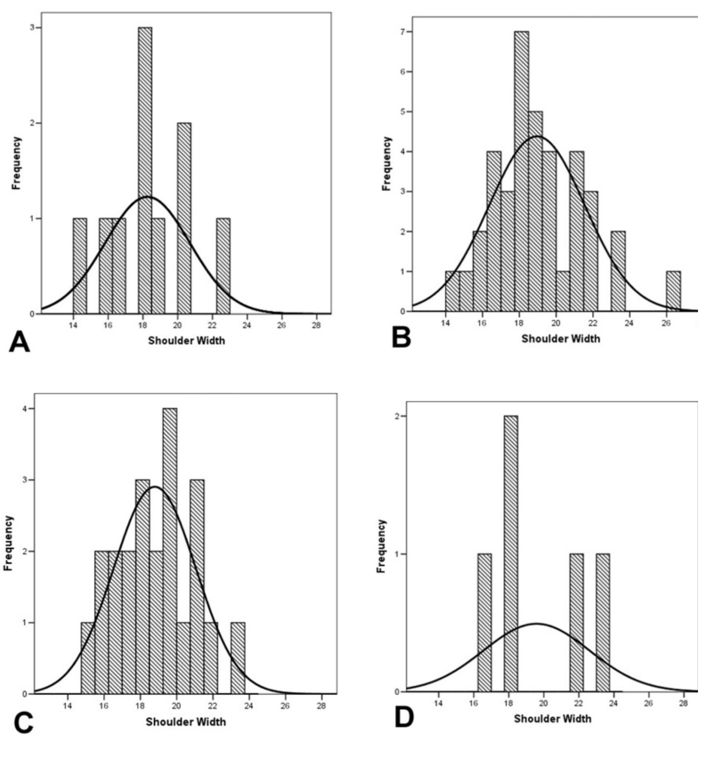


Figure 10. *Shoulder width, various samples, Crawford Knoll type points. A: Crawford Knoll site; B: Bruce Boyd site, total sample; C: Feature 9, Bruce Boyd; D: Feature 20, Bruce Boyd.*

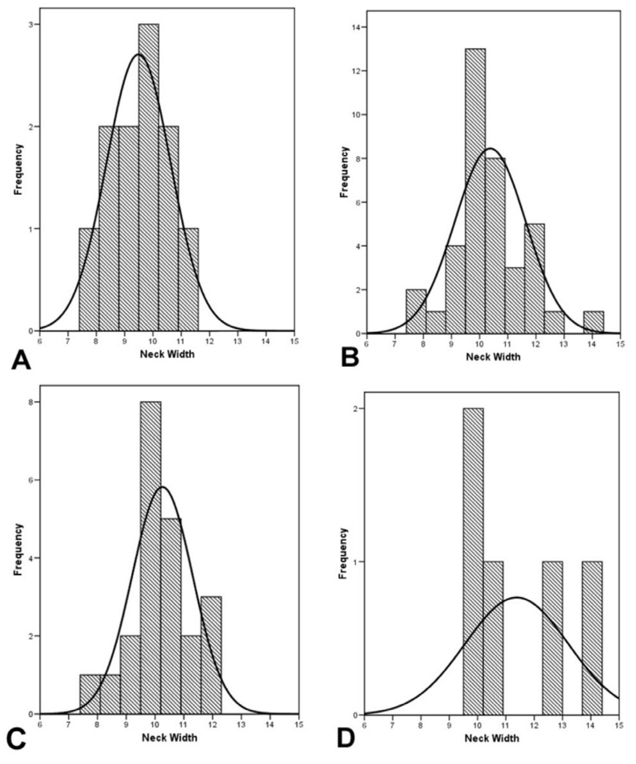


Figure 11. *Neck width, Crawford Knoll type points. A: Crawford Knoll site; B: Bruce Boyd site; C: Bruce Boyd, Feature 9; D: Bruce Boyd, Feature 20.*

in the Bruce Boyd assemblages do seem to bracket the 20 mm width that Shott (1997) suggested as a rule of thumb was the best single separator of darts and arrows in the known samples and again this seems to be more than simple coincidence. We note that ethnographic evidence overwhelmingly indicates that variability in *stone* weapon tip assemblages, rather than directly indicating use on different kinds of game, is almost always due *proximately* to use on different kinds of weapons (Ellis 1997) although these could in turn be used to hunt different types of fauna.

A similar suggestion of a bimodal distribution is evident in some other variables that some investigators have argued are useful to distinguish darts and arrows, notably neck width (e.g. Bradbury 1997; Corliss 1972; Nassaney and Pyle 1999:249) and weight (Patterson 1985). Although hampered in some cases by small sample sizes, notably for Parkhill, as was the case with shoulder width there is no suggestion of a bimodal distribution at Crawford Knoll where more items are classified as arrows (Figure 11a). Yet at Bruce Boyd as a whole (Figure 11b) and in turn, for the largest individual grave lots at that site (Feature #9 and Feature # 20; Figure 11c-d), there are suggestions of a bimodal distribution and more skewing towards the larger end with some larger outliers. At Bruce Boyd (Figure 11b-d) the split between modes seems to be around 10-11 mm. This break represents the same split between arrow and dart neck width suggested by bimodal distributions in some other analyses (Nassaney and Pyle 1999:249). Weight requires points be complete so only the Bruce Boyd and combined overall sample are relatively large but those samples do seem to have a slight bimodal distribution with a split around 3-4 gm (Figure 12). Such a distribution might also be suggested for the small Parkhill sample (amongst the complete items there is one relatively large point [4.1 gm] and five others that are all under 2 gm in weight; however, recall that previous analyses suggest the Parkhill points might be much more resharpened, something that would greatly affect weight), but there is no such suggestion of bimodality amongst the seven complete Crawford Knoll points. A split between darts and arrows

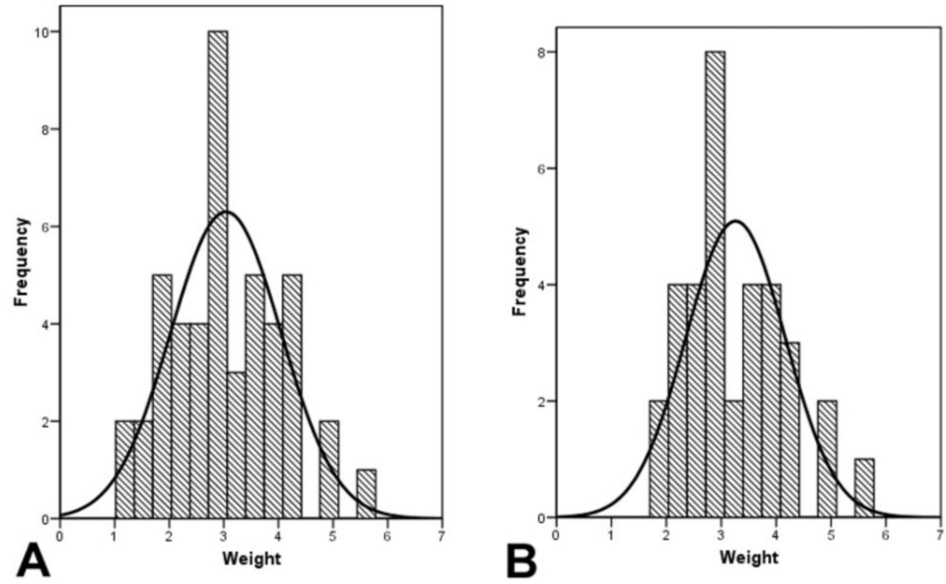


Figure 12. *Histogram of weight, Crawford Knoll type points. A: total sample; B: Bruce Boyd site.*

around 3-4 grams has been argued in some studies (Patterson 1985), so once again these suggestions of bimodal distributions correlate with other evidence.

To sum up, and although not without some ambiguity that perhaps could be resolved through analyses of larger samples, the results of the discriminant functions, backed up by other patterning in these data, suggest that in Broadpoint times (Figure 9) the dart held sway to be replaced partially by arrow use early in the Smallpoint and then by a resurgence of the spearthrower such that stone arrow tip use was greatly reduced in the last gasps of the Archaic and the subsequent Early Woodland.

If so, why was this use reduced? We think there are several potential explanations, none of which are easily assessed with present evidence. One possibility is that toward the end of the Archaic and into the Early Woodland people opted for a more standardized technique of weapon manufacture in which the same type of point could be produced for use on a shaft for either darts or spears; the points work on both weapons even though they may not be the most efficient on either. Another potential explanation concerns use for purposes other than on launched weapons. Discriminant functions may classify items as a dart or an arrow tip but they may have been used as neither. One could entertain the notion that both Ace-of-Spades points and Meadowood points (and even Broadpoints) were used as knives rather than as projectile weapons, perhaps explaining their classification as darts. In fact, as another potential explanation, and especially for Meadowood (see Beld 1991:26; Ellis and Spence 1997; Ellis et al. 1988; Granger 1978) we know that such points were made on cache blades, perhaps produced by specialists (Fox 1984:11), which were widely exchanged and which were recycled in high percentages into non-projectile tip usages as drills, perforators, end scrapers, side scrapers, gravers, knives and many other imponderables. These other usages may have required a slightly more massive biface, especially if hafted. Although they were used as arrow tips, their use for other purposes was much more important, so one was willing to accept a slightly larger and perhaps somewhat inefficient point as an arrow tip; flexibility of use was more important than precision of application.

Still another potential explanation is based on the evident fact that weapon tips can be made on a wide range of organic materials. Perhaps dart points were made on stone while arrow raw material shifted largely from stone to organic

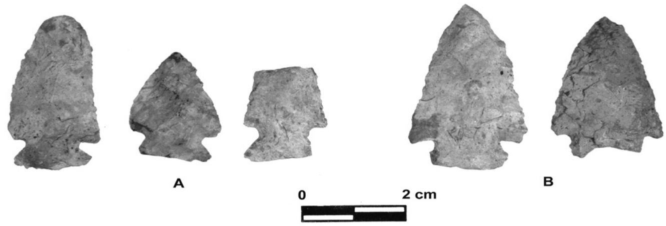


Figure 13. *Crawford Knoll type points, Feature 20, Bruce Boyd site. Points are separated into the smaller (A) and larger (B) variants, which may represent arrow and dart tips respectively (see Figure 2.10D, 2.11D).*

materials that disappeared or were reduced in use over time. Some Meadowood points were arrow tips but they are lost in the shuffle in analyzing whole assemblages. Historically, stone tips are used almost exclusively in attacking larger animals whereas smaller game animals and birds were hunted with organic tips (Ellis 1997). The bow and arrow is more useful than a spearthrower in hunting much smaller game and one suspects that prior to the introduction of the bow and arrow, devices such as traps and throwing sticks were the main technologies used to obtain smaller animals. So it is possible the main initial advantage of the bow was in stalking smaller animals and could represent a trend over time towards more use of that kind of prey using organic tips, which due to preservation problems are not represented in most assemblages. It could be that once a new weapon was introduced it required some experimentation to determine the best contexts for using these weapons and the best kinds of tips for that purpose. Initially, stone arrow points could have been used for all types of game, once their limitations in hunting smaller game were recognized by trial and error gradually more and more emphasis might have been placed on organic arrow tips.

Finally, there may be shifts over time in the specific hunting methods used. Several investigators have suggested that aside from its usefulness in hunting small game, the bow and arrow is more useful in the stalking of game by individual hunters since it can be used over greater distances from the prey with greater accuracy and can be used more silently and launched quickly (Cotterell and Kamminga 1990:180; Nassaney and Pyle 1999:259; Raymond 1986). In contrast, a main advantage of the dart is that the larger weapon and tip is potentially more lethal, having a greater mass and thus, force upon impact, and is more useful and superior at killing at shorter distances (Raymond 1986; Shott 1993). Hence, it would be more useful in situations such as communal hunting. In fact, Ian Kenyon (in Ellis et al. 1990:105) actually suggested that large Broadpoints may have been more useful in situations such as communal deer drives where stealth, accuracy and ability to hit a target at a larger distance, the main advantages of bow and arrow use, are obviated. With the early Small Point Archaic it is possible that for a time the individual stalking of game became more the norm whereas, for whatever reason, it was less important in the subsequent later Small Point Archaic and Early Woodland. For what it is worth, there are several large Broad Point sites (e.g. Kenyon 1980a, 1980b; Fisher 1997) known, as well as Meadowood ones (e.g. Ellis et al. 1988), which are suggestive of larger aggregation sites, perhaps partly for the purposes of communal hunting. In direct contrast, the known Small Point Archaic sites, especially the early dating ones are all somewhat small and ephemeral (e.g. Ellis et al. 1990:112, 2009), perhaps suggesting this scenario is a plausible one.

Accepting these kinds of explanations, or combinations thereof, as implied above one would have to argue that the bow did not wholly replace spearthrower use but continued to be used alongside it for many years. As discussed, while the bow is a superior weapon in some respects, such as being able to launch many items in succession more rapidly, it does have some major drawbacks: they are much more difficult to make such that they will work well, they place more limitations on the raw materials suitable for the launcher and projectile that require much more effort to procure, and they are much more difficult to maintain. In fact, they require so much skill and effort to make and maintain that historically many societies had specialists who produced bows and arrows (Driver and Massey 1957:371; Du Bois 1940; Wallace and Hoebel 1952:101). Some have actually argued that the bow and arrow only became the weapon of choice in the Late Woodland because the ability to launch several items rapidly and in quick succession made them much more useful in times of increasing evidence for conflict (Blitz 1988).

Conclusions

To conclude, based on present evidence, we find it difficult to explain the use of many small Crawford Knoll points as anything other than arrow tips and we are especially impressed by the suggestions of bimodal size distributions in the Bruce Boyd assemblages and the suggestions that these differences mirror the same measurements distinguishing darts and arrows reported in other studies. Of course, the bow and arrow could have been introduced even earlier and as we noted, Ian Kenyon (1980c) suggested Lamoka points, which are poorly represented in southwestern most Ontario in a discrete cultural context, were arrow tips as well. However, we need to have much more data on all of these developments in order to fully understand the possible significance of our observations. What is badly needed is better knowledge of settlement and subsistence practices. It is very difficult to evaluate the reasoning and causes behind any shifts in weapon technology without that contextual information. While our knowledge of the end of the Archaic may be better than that for any earlier Archaic developments, it is still woefully inadequate.

Acknowledgements. We thank Mike Shott who leant an eye to an earlier draft and provided some much needed feedback, and several individuals who allowed us access to collections: Brian Deller, Neal Ferris, Paul Lennox and of course, Michael Wishart Spence. We are extremely pleased to be able to include this paper is a volume in Mike's honour and hope that he will not be too critical of it!

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