Use life and curation in New Guinea experimental used flakes

Michael J. Shott\textsuperscript{a,}\textsuperscript{*}, Paul Sillitoe\textsuperscript{b}

\textsuperscript{a}Department of Sociology, Anthropology & Criminology, University of Northern Iowa, Cedar Falls, IA 50614-0513, USA
\textsuperscript{b}Department of Anthropology, University of Durham, 43 Old Elvet, Durham DH1 3HN, UK

Received 9 August 2004; received in revised form 18 November 2004

Abstract

In 1983, Sillitoe timed New Guinea Wola men as they used chert flakes in customary tasks. We use the resulting data to distinguish the familiar but often conflated concepts of use life and curation, defining curation as the ratio of realized to maximum utility. We compile distributions of time-to-discard, analogous to mortality profiles in demography and zooarchaeology and failure distributions in engineering, and propose a quantitative curation measure, the Gompertz-Makeham parameter, to characterize them. We compare this curation measure to use-life distributions. Despite use life measured only in minutes, curation varies independently of use life in different tool distributions. Some tools were well curated despite brief use. Thus, use-life can be short when curation is high; the quantities are independent. We discuss the implications of the ability to measure, not just subjectively judge, curation.

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Keywords: Curation; Use life; Wola; Survivorship; Gompertz-Makeham

1. Introduction

When the subject is stone, most archaeologists think of retouched tools. They naturally engage our interest for their virtuosity and what they imply of culturally patterned manufacture, expression and activity. Yet around the world retouched tools are outnumbered by more prosaic ones. Among these are used flakes (we favor “used” over the more common “utilized” as plainer, shorter and identical in meaning) that functioned without modification and often without hafting.

In New Guinea and elsewhere, used flakes are the most abundant chipped stone tools. Accordingly, their importance today is “out of proportion to their very small size” [11, p. 80]. So too in the past; in New Guinea prehistory “we are dependent to a significant extent on the study and analysis of simple stone tools” [45, p. 97] like used flakes. These flakes have the further virtue of brief use and presumably immediate discard. Therefore, they directly record kinds and amounts of tool-using activity. In contrast, “curated” tools could be used, retouched and transported between several places before discard, which complicates their archaeological association with kind, amount and place of use.

Despite their prosaic nature, used flakes may improve understanding of how the archaeological record formed. When archaeology was innocent of formation theory, it was a simple matter to interpret stone-tool assemblages. If one tool type was more abundant than another, this was because it was used more. Now we know that type proportions in assemblages are complex functions of amounts and rates of use but also use life and perhaps curation [1,32].

As with other stone tools, studies of used flakes involve technology and (trivially) use. Yet archaeology pays little attention to how used flakes were discarded to enter the record, despite the fact that “Discard is...of
crucial importance to the archaeologist” [46, p. 35]. Usually, flakes were discarded quickly, most ethnographic accounts showing that flakes were used briefly [e.g., 15]. By common reasoning, they must therefore be “expedient,” not curated, tools. But curation has many meanings (e.g., anticipation of future use, carrying between places), which compromise its analytical integrity; rejecting most of them, we define curation as the relationship between realized and maximum utility [33]. Use life is simply the service life of objects. Use life and curation both are properties of individual tools and average properties of sets of tools.

Archaeologists often equate use life and curation, on the logic that things that last long times are highly curated and things that are used and wear out or break quickly are little curated (“expedient” in common parlance) [e.g., 13, p. 47; 24, p. 95; 25]. Theoretically, however, use life and curation (as defined above) are distinct, even if they can co-vary. That is, tools can be both shortlived and highly curated or longlived and little curated [33].

Theoretical independence is easily imagined, but its empirical demonstration is a different matter. We demonstrate it using Wola used flakes from highland New Guinea. First we briefly summarize other accounts of used flakes and describe Wola data. Then we consider use life and curation, and ways to measure them indirectly in archaeological data. In the Wola case, use life is known from direct observation. Estimating curation independently of observed use life, we determine if the two quantities are related or separate.

2. Ethnographic descriptions of used flakes

Ethnographic documentation is poor for most kinds of stone tools. Fortunately, a number of sources describe the use of unmodified flakes from New Guinea and elsewhere. It is both impractical and unnecessary to describe each ethnographic source in detail; the most salient details of manufacture, use and worked material are broadly similar in most of them.

Used flakes were selected from the debris of core reduction, often bipolar. Flake size and form vary considerably in such technologies, allowing wide latitude in choice of specimens. The prehistoric technology of used-flake production may have been both more diverse and better controlled than is typical of most ethnographic accounts, which are from cultures that possessed little if any other flaked-stone technology so had no apparent need for efficient or elaborate reduction technologies.

Most flakes were used briefly, often for minutes only, sometimes for hours and rarely for days or longer [e.g., 41, p. 35]. Most were hand-held but some were hafted [e.g., 15; 44, p. 317, Plate XVI; 45, Figs. 5–8]. By definition, used flakes were not retouched [cf. 9, p. 164–165; 30, p. 20, Figs. 96–100; 44, p. 315] but discarded when dulled or when the task at hand was completed. That is, flakes were used until they were used up or no longer needed, and both eventualities occurred quickly [20, p. 16; 22, p. 403–404; 29, p. 14; but see 5, p. 290]; used flakes rarely were curated, in one sense of that term, by being carried from place to place over some length of time [2]. There are exceptions; no Dani man, for instance, “is without one or several of these in his toolkit” [11, p. 297].

In New Guinea, used flakes were ubiquitous and mundane. They served in all tasks for which stone was required and groundstone axes could not be or were not used. Elsewhere, used flakes were used either to the exclusion of other tool types or according to circumstance among people who also made retouched tools.

As a class, used flakes were quintessential multifunctional tools used on wood to make arrow shafts and many other tools, on bone, on shell, even to circumference [9,11,14,15,23,48]. Their kinetics or motor mechanics of use were similarly diverse, including scraping and planning, engraving, cutting, shredding, and boring or drilling. Although multifunctional as a class, many used flakes were used only on one material and in one way owing to their short use lives [cf. 5, p. 319].

Measurements of individual flakes rarely are reported in ethnographic sources. New Guinea Dani flakes varied from 15 to 50 mm in length, although few exceeded 30 mm [11, p. 297]. Used flakes averaged about 30–40 mm in length, 20–30 mm in width, and 9–12 mm in thickness among Duna speakers; hafted specimens were smaller on average in all dimensions [47, Tables 5–7; 48, Table 7.3]. The former also reported mean weights of 5–9 g. Working-edge angles varied narrowly between 50° and 60°. The only source consulted that tested for between-group differences in the dimensions and other attributes of used flakes found none, while within-group variation was considerable but patterned [47]. Used flake size and form did not pattern with social or other identity-conscious group, if anyone suspected they did, but neither was any old flake considered suitable. Instead, there were cross-cultural functional criteria that somewhat limited the range of acceptable variation.

3. Wola data

For over two decades, Sillitoe [40,42] studied the highland New Guinea Wola (Fig. 1), tribal horticulturists who raise pigs and grow sweet potato, taro and other crops. As elsewhere in New Guinea, used flakes are common among the Wola [41,42]. At the request of interested archaeologists, Sillitoe asked Wola men to use chert flakes in customary ways and tasks, recording the time that flakes were used. Other sources [12,43]
described the tools under study and activities performed. Twelve men participated, but five accounted for use of 90 of the 104 flakes recorded. Flakes were knapped from three cores of the same local chert. They were numbered by core; for example, “42A” signifies flake 42 from Core A. By no means were all knapped flakes used in the experiment; only used ones were analyzed. Men used flakes to scrape, pare or carve wood and plants (Fig. 2), or to butcher pigs and work bone. Most specimens were used in one task. Several were used in the same task, paring of a pig bone [12], some in more than one task (e.g., 52A, used first to pare pig bone, as above, then to pare palmwood). Uses, kinetics of use, and circumstances of discard were as faithful to original conditions as the context permitted. Three flakes were hafted among the 104 recorded; they are too few for separate treatment, so were analyzed with other flakes. (Hafted flakes might be expected to experience longer use than unhafted ones, but on average Wola hafted flakes had [statistically insignificant; $t = 0.93$, $P = 0.35$] shorter use lives.) Flakes were used until depleted or until task completion even if serviceable. The latter practice is commonly inferred for prehistoric used flakes as well [e.g., 18, p. 803]. At least one (57A) was discarded as worthless after brief use.

Compared to other sources that report metric data, Wola used flakes are considerably larger and much heavier, with a wider range but lower mean value of edge angle (Table 1). Mean weight of Wola flakes is an order of magnitude higher than Duna figures [48, Table 7.3], and that for all flakes, not just the smaller hafted ones in the latter source. The Wola weight distribution is right-skewed, with a few large, heavy flakes. White et al.

![Fig. 1. Wola location map.](image1)

![Fig. 2. Paring bamboo with a used flake.](image2)
Fig. 3. Shape ratio to weight in Wola flakes.

Fig. 4. Frequency distribution of flake use life. A. Among used flakes. B. Used flakes compared to other Wola types.
with little predictive power. As elsewhere, size has something to do with mean use life, but probably because of their joint determination by other factors. Possible relationships between size and use-life distribution remain to be studied.

4. Use life and curation

Use life can be measured in time on scales from seconds to decades, but also in other units and on other scales. Use life in experimental dart points, for instance, can be measured in number of firings [35]. In scrapers it can be measured in number of strokes [e.g. 3]. The range of uses and materials to which Wola flakes were put and the impracticality of counting actions like strokes or cuts made such measures impossible.

Use life in tool types can be described as a simple mean value. “Cooking ollas last for three months.” “Groundstone axes last for 10 years.” Yet in many cases there is much dispersion of use-life values around the mean. “Cooking ollas last from one week to six months.” “Groundstone axes last from five years to 25.” Then the mean value is less useful, and certainly no more valuable than knowing and explaining the distribution of individual observations around it. The relative frequency or distribution of use life values around the mean not only is worth knowing in its own right but, independently of the mean, influences how the archaeological record forms and reveals modes or causes of discard [38].

So too for curation. But defining it as the ratio of realized to maximum utility [33], p. 269–271] begs a question: What is “utility”? In archaeological thought, utility has several meanings [7, p. 40–42; 19, p. 430–432; 33, p. 269–271]; for our purposes, it signifies the amount of use that a tool can supply in time, tasks performed, or other measures of use. This concept is equivalent to “use-life utility” [7, p. 41], “number of uses” [31, p. 54], and “remnant use-life” [6, p. 26]. For stone tools that were resharpened, maximum utility is the amount of reduction possible between first use and discard, realized utility simply the amount that each specimen underwent. Therefore, measuring utility requires knowing the amount of usable material that a tool contained originally [19; 33, p. 270].

Some archaeologists doubt that stone tools changed in size and form as they were resharpened in use, but reduction effects are well documented in experiments, ethnography, and archaeological tools [e.g. 16]. Utility can be approximated by object mass, size or cross-sectional geometry [19, p. 429; 36]. As one example, detailed metric and technological analysis, including specimens broken at various stages of use and resharpening, revealed the range of length reduction that North American Paleoindian flake tools experienced from first use to discard [10]. Reduction measures curation, and amount of reduction measures amount of curation. Reduction occurs as a function of time, if irregularly, so curation estimated by reduction is an indirect measure of time. No wonder that some archaeologists equate use life and curation; one is measured in units of time and the other increases indirectly through time.

Use life is measured directly in ethnographic specimens like Wola flakes, but measuring curation requires measurement of utility, both realized and potential. Because Wola used flakes were not retouched and reduced, their curation rate cannot be estimated by reduction. Fortunately, it can be approximated by analogy to the distribution of death (in demography) or failure (in engineering reliability), a method that applies equally to discarded ethnographic and archaeological tools. As above, curation is a property of individual tools and also of entire types of them. So is the distribution of any measurement of tools like their length. Measured for each specimen in a type, the distribution of its values is a collective description. Curation can be expressed as cumulative survivorship plotted against measures like age-at-discard [33, Fig. 1; 38]. At maximum curation, all specimens survive to the point of maximum utility. At progressively lower curation rates fewer specimens survive to maximum utility and more fail or are discarded at lower values of realized utility.

A hypothetical example illustrates the relationship between curation and death, failure or discard distribution. Consider three tool types of 10 specimens each, in all of which maximum utility is 10 units of time, performance or reduction (Table 2). In Type 1, all specimens are used to maximum utility. This type is maximally curated, and its cumulative survivorship appears as Curve 1 in Fig. 5. In Type 2, one specimen fails at t1, one at t2, one at t3 and so on to t10. Its
cumulative survivorship curve appears as Curve 2 in Fig. 5. In Type 3, most tools fail in $t_1$ or $t_2$ and only one survives to $t_{10}$. Type 3 is poorly curated and its cumulative survivorship appears as Curve 3 in Fig. 5.

Distributions are given in hypothetical cases but not obviously known in prehistoric ones. If archaeologists can measure tools on scales that correlate their reduction with utility obtained (e.g., degree of reduction from original size), then reduction distributions are survivorship or curation curves [e.g. 33, Fig. 1]. As in demography and reliability analysis, curves can be fitted to mathematical models that supply the theoretical content to interpret them and to explain differences between them.

5. Mathematical models

Mathematical models may seem esoteric when applied to a collection of Wola used flakes, but are not so pedantic as they may seem. First, models describe data, as do simple statistics, but they also explain patterns in them [38]. Second, models facilitate the comparison of sets of objects like tool types or subsets of the same type made in different ways, places or of different materials. Third, models are parsimonious in both description and explanation.

Several mathematical models have been applied in engineering failure analysis and demographic analysis. We use the Weibull model for its generality, its theoretical content, its popularity in other fields, and because there is a growing body of Weibull application to experimental and archaeological specimens [35,38,39]. In particular, the Weibull $\beta$ parameter identifies chance or attrition as the cause of discard, depending upon its value [21,35,38]. If $\beta$ is near a value of 1, failure is by chance. If $\beta$ significantly exceeds 1, failure is by attrition. We use the Gompertz-Makeham model because of its popularity in demography, its suitability as a model of aging, and because it is robust; most other demographic models are “extensions of the Gompertz-Makeham model” [49, p. 147]. Gompertz-Makeham $a$ and $b$ parameters measure the scale and shape or slope of age- or time-related failure, and its $c$ parameter the constant probability of chance failure [49, p. 146]. Gompertz-Makeham $a$ sometimes is called “baseline mortality”; $b$ measures rate of aging.

As before [35; 38], we used a spreadsheet method to estimate Weibull parameters, and McCool’s [21, p. 4] method and unpublished tables along with Johnson’s [17, Fig. 23] chart to estimate 95 percent confidence limits of $\beta$. We used Winmodest [27], a computer-intensive method that produces maximum likelihood estimates (MLE) of Gompertz-Makeham parameters, and “decomposes” or parses [28] differences in mean longevity between distributions by the contributions to them made by scale and slope parameters and by chance. Winmodest estimates model parameters from starting values supplied either by default or estimated by the user. We estimated $a$ and $b$ in two ways: 1) from Winmodest default starting values; and 2) from the intercept and slope, respectively, of regression of In-mortality rate upon age (S. Pletcher, personal communication 2004). In most cases, the approaches yielded identical results, indicating that MLE parameter estimates are robust. When they did not, we used regression values as starting parameters.

Fig. 5 shows the Gompertz-Makeham $b$ parameter for each hypothetical distribution from Table 2. Values clearly pattern with curation rate, from a low of 0.01 in poorly curated Curve 3 to a high of 2.08 in highly curated Curve 1. The pattern suggests that Gompertz-Makeham $b$ correlates with the form of survivorship curves; low $b$ values occur with concave distributions and high ones with convex distributions. We know of no other stone-tool or, for that matter, artifact examples, but demographic data corroborate the pattern. For instance, there is a correlation between Gompertz-Makeham $b$ and the form of human survivorship curves [8, Table 1, Fig. 2c] (Fig. 6). A concave distribution – the “West Level 1” that models low survivorship rates in pre-industrial or modern impoverished contexts – yields a low $b$ value. A convex distribution – as for modern Sweden, with high survivorship rates–yields a high $b$ value. In this comparison, survivorship equals curation, higher survivorship signifying greater curation.

We conclude that Gompertz-Makeham $b$ is a summary measure of the form of cumulative survivorship distributions such that higher $b$ values indicate greater convexity and higher survivorship rates per age interval. Because those distributions vary with curation rate, it follows that $b$ also estimates that quantity. This is no surprise, because survivorship is the demographic equivalent of curation as we define the latter. The higher a population’s or cohort’s survivorship, the more convex the shape of its curve, the more individuals live to greater ages and the higher the mean age at death. The more curated a tool type, the more convex its
survivorship curve, the more specimens that survive to greater ages before discard and the higher the mean use life.

Therefore, Gompertz-Makeham $b$ correlates with survivorship and, by extension, curation rate. Unfortunately, it does not scale uniformly with either quantity. Customarily, data are expressed on a relative scale for survivorship: proportions between 1 at birth for all members of a cohort and 0 at death of the last individual. But age is expressed in absolute values. Thus, survivorship curves are plotted with a relative scale for the ordinate and an absolute one for the abscissa. The shape of curves and values of estimated model parameters are influenced by this format. In comparing curation rates between tool types, assemblages, or by other meaningful criteria, therefore, the shape of survivorship curves and the value of model parameters are scale-dependent. The wider the range of age variation, the lower the $b$ value. For example, a tool type whose specimens lasted for, say, anywhere between one and ten days might have an identical shape to its survivorship distribution and thus be as well or poorly curated as one whose specimens lasted from one to 100 days. Yet the first type would have a higher $b$ value purely because of the narrower age range of its survivorship distribution.

Scale differences in human mortality range are relatively slight. Because a few individuals survive to great age even in populations with low life expectancy, there is relatively little difference between populations in the range of age-at-death. Demographers routinely express survivorship as a function of absolute age and legitimately compare demographic samples because their model parameters are little affected by variation in age range. What is legitimate in comparing human populations is not so in comparing humans to, say, butterflies, which do not live nearly as long no matter their survivorship rates. Such a comparison is compromised if age is measured on an absolute scale.

In the same way, archaeological and ethnographic tool types are apt to vary widely in age. Partly this owes to different units of measurement. Age in dart points, for example, can be expressed in number of uses, which rarely exceeds 10 and averages less than five in experimental studies [35, Table 3]. Age in Wola used flakes, measured in minutes, and in other Wola tool types, measured in months or years [37], occupy much wider ranges. Scale differences may owe as well to tool size and reduction. For instance, bifaces typically are much larger than are unifaces. Measured by amount of reduction, biface ages can vary over a wider range than can uniface ages. In general, different units of age measurement and the range of resulting values complicate analysis. In curation analysis, archaeologists might need to compare the equivalent of people and butterflies, which is not legitimate using absolute age scales. Biologists long ago confronted similar problems of comparability, and solved them by rescaling specimen age as fractions of each type’s mean age-at-death [e.g. 26]. If a taxon’s mean age-at-death is, say, 10 in whatever suitable unit of time or age and one individual died at age 5, its age would be expressed as 5/10 = 0.5. Similarly, age for an individual who died at 20 would be rescaled to 20/10 = 2.0. In effect, this practice calibrates original survivorship data to common time scales.

The mean is a measure of central tendency that is strictly valid only for normal distributions. If two absolute survivorship distributions are equally skewed, bimodal or otherwise non-normal, their rescalings to fractions of mean age-at-death or use life are equally
biased so cancel out. If one distribution is normal and another skewed, their comparison by rescaling is unequally biased, which may affect analysis. We acknowledge this possibility but assume that its effects are slight in Wola data.

We call age expressed in original units “absolute” “age” and age rescaled to fractions of mean use life “relative age.” To determine whether survivorship and curation calculated from absolute and relative ages differ, we converted Table 2’s absolute ages to relative ones using each distribution’s mean use life. Results appear in Table 3. (Distribution 2’s monotonic survivorship decline in Table 2 and Fig. 5 is altered slightly because of the intervals of relative age used.) Although b values are much higher for relative age (Table 4), the pattern persists: the least curated distribution has the lowest value by far, the best curated distribution the highest value. We conclude that measurement of the difference in curation rate between types is preserved when survivorship is rescaled from absolute to relative ages. In analysis, however, we distinguish Gompertz-Makeham b estimated from absolute and relative age.

### 6. Analysis

Shott and Sillitoe [38] compared death or failure distributions in some stone-tool types, including Paleoindian flakehavers from the Bull Brook site in the northeastern United States [10]. Because these tools are archaeological, use life and its distribution are not measured on the same scale as for Wola specimens. Flakehavers were hafted and distally retouched; their use life is approximated by degree or amount of reduction from original length. Briefly, the difference between reconstructed original length and mean reduced length is 54 mm, which is an estimate of maximum utility or the range over which utility varies. As above, maximum use life in Wola used flakes is 54 minutes, which is their maximum utility or range of utility. Despite their differences from Wola used flakes, flakehavers are a useful class for comparison because presumably they were used to scrape or shave as were Wola specimens.

#### 6.1. Curation rates in used flakes and flakehavers

By chance, then, the scale and range of use-life variation is identical between flakehavers and Wola flakes, which permits their direct comparison free of the scale effects of age measurement on Gompertz-Makeham b noted above. Nevertheless, we report b estimated from both absolute and relative age. (Both types’ distributions are slightly right-skewed, so the mean is a fair measure of central tendency for calculating relative age.) Age units are length reduction for flakehavers and time for Wola used flakes. Strictly, then, the comparison is arbitrary; we make it only for heuristic purposes. Moreover, even though each type’s empirical maximum is 54, we do not know if this is the theoretical maximum use life in time, performance or amount of reduction for all tools (i.e., their point of depletion) or merely the maximum value that one tool happened to attain. That is, 54 may mark the point of utter depletion, but perhaps 100 or 273 does instead and no specimen happened to reach those higher values. If the latter, the 54-minute maximum underestimates use life and exaggerates curation rate.

For comparison, we treat both flakehavers and Wola used flakes as integral types. By design, form and inferred use, flakehavers deserve this treatment, but used flakes vary considerably in all salient respects. They are not homogeneous, and form a type only for analytical purposes. Fifty-four minutes is the longest time that any flake was used, but perhaps by virtue of their size, form or worked material some could have been used only for, say, 12 or 37 minutes. If the latter, the 54-minute maximum exaggerates their use life and underestimates their curation rate. Of course, the 54-mm range of reduction in Bull Brook flakehavers also could exaggerate amount of reduction in some specimens there. The possible bias in estimating maximum utility from an empirical maximum value applies equally to both tool classes. Neither estimate is perfect; both are used for heuristic purposes.

Fig. 7 compares distributions of absolute and relative age in Paleoindian flakehavers and Wola used flakes. In both, Weibull β significantly exceeds 1, so discard is by attrition. In absolute age, the flakehaver distribution better approximates Curves 1 and 2 of Fig. 5, the used-flake distribution Curve 3. Gompertz-Makeham b patterns with the distributions’ forms as in Figs. 5 and 6. Winmodest calculates the estimates’ 95% confidence intervals, which do not overlap between flakehavers and Wola flakes using either age scale. By these

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean use life (min)</th>
<th>β</th>
<th>“absolute”</th>
<th>“relative”</th>
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<tr>
<td>All used flakes</td>
<td>16.7</td>
<td>1.52 (/&gt;1)</td>
<td>0.03</td>
<td>0.58</td>
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<tr>
<td>BB flakehavers</td>
<td>na</td>
<td>2.78</td>
<td>0.16</td>
<td>5.97</td>
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<table>
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<tr>
<th>Action and material worked</th>
<th>Mean use life (min)</th>
<th>β</th>
<th>“absolute”</th>
<th>“relative”</th>
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</thead>
<tbody>
<tr>
<td>Wood, etc.</td>
<td>17.6</td>
<td>1.71 (/&gt;1)</td>
<td>0.04</td>
<td>0.65</td>
</tr>
<tr>
<td>Meat, etc.</td>
<td>7.4</td>
<td>1.02 (/&gt;1)</td>
<td>1.00</td>
<td>7.39</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>User</th>
<th>Mean use life (min)</th>
<th>β</th>
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<th>“relative”</th>
</tr>
</thead>
<tbody>
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<td>1</td>
<td>15.3</td>
<td>1.52 (/&gt;1)</td>
<td>0.06</td>
<td>0.86</td>
</tr>
<tr>
<td>3</td>
<td>22.7</td>
<td>1.15 (/&gt;1)</td>
<td>0.17</td>
<td>3.55</td>
</tr>
<tr>
<td>6</td>
<td>10.5</td>
<td>1.75 (/&gt;1)</td>
<td>0.12</td>
<td>1.23</td>
</tr>
<tr>
<td>8</td>
<td>23.8</td>
<td>1.75 (/&gt;1)</td>
<td>0.05</td>
<td>1.08</td>
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<tr>
<td>10</td>
<td>16.5</td>
<td>1.72 (/&gt;1)</td>
<td>0.75</td>
<td>7.39</td>
</tr>
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</table>
measures, hafted and retouched flakeshavers were better curated than were hand-held and unretouched used flakes.

6.2. Curation rate by subsets of used flakes

Comparing archaeological flakeshavers and Wola used flakes may have merely heuristic value, but the latter can be subdivided legitimately for comparison and analysis. One meaningful distinction in Wola data is by action and worked material, between flakes used to scrape or shave wood or rattan and flakes used to cut meat and scrape bone. Mean use life and parameter estimates appear in Table 4; cumulative survivorship is plotted in Fig. 8. Because maximum use life is considerably higher in flakes used on wood and rattan, absolute-age curves have different ranges and therefore do not overlap. Curves of relative age are similar because of their lower x-axis range and the inherent constraint of survivorship curves never to increase with age. Casual inspection of constrained curves is unreliable; MLE parameter estimation is required. Wood-working flakes have significantly longer use lives than flakes used on meat or bone ($t = 2.5, P = 0.02$). Yet they fail by attrition; as elsewhere, “Working of wood quickly consumes stone tools” [4, p. 428]. Wood-working flakes have lower Gompertz-Makeham $b$ values than meat- and bone-working ones; again, 95% confidence intervals do not overlap. Longevity of flakes used to scrape wood is higher but curation is lower than in flakes used on meat and bone. Use life and curation are independent.

Winmodest “decomposition” analysis parses differences in longevity between groups into relative contributions of the three Gompertz-Makeham parameters. Using it, we parsed the difference between wood- and meat-working flakes. Results were reliable using Pletcher’s [27]
analysts. We define it as a variable quantity to measure, rate effects on tools and assemblages. Their independence requires distinguishing their separate, which can be independent of how long they are used. Curation is how extensively or thoroughly they are used, abundance. Use life simply is how long things last. Have been cited as causes of tool design, distribution and assemblages.

Curation is a familiar but ambiguous concept to lithic analysts. We define it as a variable quantity to measure, not a categorical quality to invoke. In tools, curation is the ratio of realized to maximum utility, in distributions the Gompertz-Makeham parameter. So conceived and measured, curation is no interpretive trope but a quantity that varies by degree among tools and assemblages. It is high or low, not just present or absent. This reconceptualization alone clarifies its meaning. But curation, like use life, influences the size and composition of assemblages; well-curated types are discarded less often than poorly curated ones for equal amounts or rates of use [38, p. 341–342]. In retouched tools, curation increases with degree of reduction, which changes not only tools’ size and form but, depending on the typology used, their type assignment as well [16]. The better and more precisely that we measure curation, the better we control the typological effects of reduction and improve our inferences from stone tools.

Acknowledgements

This is a revised version of a paper presented at the 69th Annual Meeting of the Society for American Archaeology, Montreal, April 2004. Thanks go to Briana Pobiner and David Braun for their invitation to contribute. We thank Timothy Gage and the Annual Review of Anthropology for permission to reproduce Fig. 6, and four anonymous reviewers for their comments. Our greatest debt is to Sillitoe’s Wola colleagues.

References


7. Conclusion

Curation and use life both are important and both have been cited as causes of tool design, distribution and abundance. Use life simply is how long things last. Curation is how extensively or thoroughly they are used, which can be independent of how long they are used. Their independence requires distinguishing their separate effects on tools and assemblages.

Curation is a familiar but ambiguous concept to lithic analysts. We define it as a variable quantity to measure,


[23] S.D. Fletcher, WINMODEST Documentation, Unpublished ms. on file, Baylor University Department of Medicine, Houston, TX, 1999.


