DAMAXIS – Danish Mesolithic Axes Information System

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Abstract. DAMAXIS is a tool built to create a typology for Mesolithic flake axes and to investigate whether geographical and / or temporal distributions can be detected. It is a state-of-the-art dedicated IT system, programmed in HTML and JavaScript. It contains different statistical methods but especially the availability of the digital images data base which enables continuous back and forth switching between the abstract calculations and the individual axes makes DAMAXIS a sophisticated and powerful tool for creating a typology. In this paper a description of the DAMAXIS system is given. A following paper will handle the results.

1. Introduction

The development of DAMAXIS was undertaken to investigate whether it is possible to create a typology of a set of well-defined types, combined with an algorithm to determine

- Whether an object belongs in the typology and if so
- Of which type the object is

The research is also an experiment in applying modern IT to an old an well known problem. The first step in this research was a small investigation into an existing typology for Roman white ware flagons, to see whether it was possible to distil from this typology (which consists mainly of descriptions and drawings of the flagons) a set of rules based on morphologic parameters that can be used as an algorithm to determine to which type an individual flagon belongs. The result was that only six morphological parameters were sufficient to define these rules (Mom 2003).

The development of DAMAXIS is a second step in this typological research: here the prime target is to see whether it is possible to create a new typology instead of re-designing an existing one.

The reason to take Mesolithic flake axes was several:

- It is a very simple type of artefact: a set of about 15 parameters is sufficient to capture its relevant morphological properties
- Currently no morphological typology for Mesolithic flake axes is in use (but see e.g. Andersson 1975)
- Many Mesolithic flake axes are available from the collections of the Danish museums.

The current DAMAXIS system is a combination of a graphical interface to invoke the different features of the system, on top of a data base containing numerical data and digital images of about 150 flake axes from Mesolithic excavations in Denmark. It is programmed in HTML and JavaScript to enable quick deployment over the Internet.

2. The Sites

In Denmark museums are responsible for doing excavations and the subsequent storage and administration of the finds. The Moesgård museum in Aarhus has in its store rooms the finds of some 5000 excavations and stray finds. From these about a hundred excavations cover the Mesolithic period.

The amount of material per Mesolithic site varies enormous: there are sites of which the finds can be stored in a container the size of a shoe box, while others occupy shelves and shelves. The same spread was observed regarding the types of finds: some excavations produced (relatively) many flake axes, while others had none at all. As the target of this phase of the project was to build the system and to get acquainted with the material in order to determine descriptive parameters for the axes, it was not regarded as a problem that the set of axes to use came from a rather inhomogeneous environment.

In Fig. 1 a map of Mesolithic Denmark is presented (taken from Jensen 1982) with markers indicating the find spots.

Table 1 shows how many flake axes of each excavations was used.

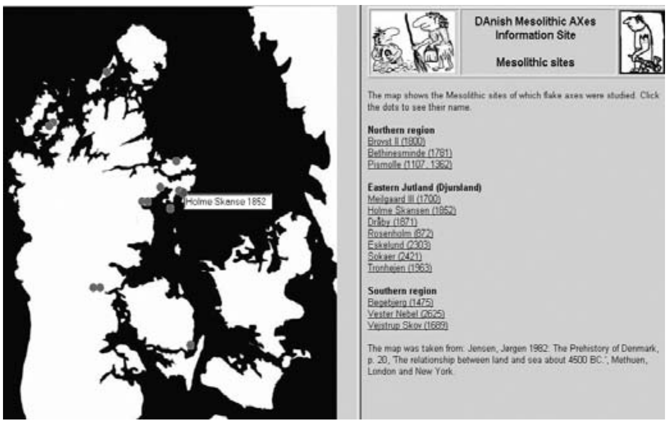


Fig. 1. Mesolithic Denmark.

Site	*# flake axes*
Bethinesminde	8
Bøgebjerg	5
Brovst II	1
Dråby	3
Eskelund	1
Holme Skansen	64
Meilgaard III	16
Pismølle	3
Rosenholm	3
Søkær	13
Tronhøjen	4
Vejstrup Skov	1
Vester Nebel	5

Table 1. Origins of flake axes.

3. The Axes

Denmark is well known for its large abundance of good quality flint, and the resulting prehistoric flint knapping practices have produced enormous amounts of artefacts. Finds of hafted axes and use-wear analysis indicate that flake axes were used for the processing of wood. When newly produced, the cutting edge of a flake axe is sharp as a razor blade, so in the hand of a skilled person very fine wood-work can be done (Eriksen 2000). It took a skilled flint knapper presumably less than five minutes to create a new flake axe. Fig. 2 shows an example of a flake axe.

Fig. 2. Flake axe. The cutting edge points to the left.

4. Parameters

The core processes in the typology branch are: describing and comparing. An artefact must be described, using a set of predefined parameters that enable later comparisons. These parameters are analytical categories defined by the researcher. In first instance, the following parameters were chosen to describe the flake axes:

- Weight
- Maximum length
- Maximum width
- Maximum height
- Number of scars (on ventral/dorsal side and platform)
- Lengths of edges (cutting edge, side edges, platform)
- Curvature of edges (cutting edge, side edges, platform)
- Angle of cutting edge
- Shape of platform
- Width of platform
- Skewness
- Irregularity in shape
- Irregularity in coarseness

Curvature and coarseness and shape are quantitative parameters. These qualitative parameters are 'estimated' by the observer. A certain measure of subjectivity is unavoidable so caution is necessary.

The curvature parameter can have values convex, slightly convex, straight, irregular, curved, concave and slightly concave. The coarseness parameter can have values very coarse, coarse, medium and fine. The shape of the platform is edge, triangular, rectangular, oval, point, or irregular. Skewness is defined as a ratio:

Skewness = 2*Abs(L1–L2)/(L1+L2)

where L1 and L2 are the lengths of the two side edges of the axe. When the axe is symmetric and the two side edges have equal lengths then the skewness is zero.

The irregularity parameters are implemented in the system using distance tables. If e.g. both side edges of the axe are convex, then the distance is zero. If, however, the sides have different curvatures (e.g. one is straight and one is convex) then this corresponds to a difference which is translated into a distance. See table 2 for a simplified example.

Simplified Distance table	Convex	Slightly convex	Straight	Concave
Convex	0	1	2	4
Slightly convex	1	0	1	3
Straight	2	1	0	2
Concave	4	3	2	0

Table 2. Distance table for shapes.

It is expected that, to set up a typology for these axes, about 3 parameters should be sufficient but this is currently not more than an educated guess, based on the simple nature of the artefact.

5. The Images Data Base

A very important part of the DAMAXIS system is the images data base. Of each axe, four pictures were taken (see e.g. Fig. 7):

- Dorsal side
- Ventral side
- ide view
- Cutting edge

These images take the place of the actual axes when using the system. The images are available at all times and enable a continuous inspection of the sorting and comparison results. For reference purposes these images are also organised in digital images albums also, sorted by site. (see Fig. 3).

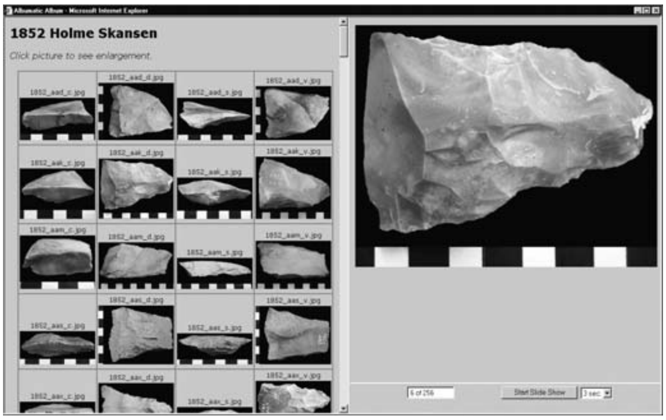


Fig. 3. Digital images album.

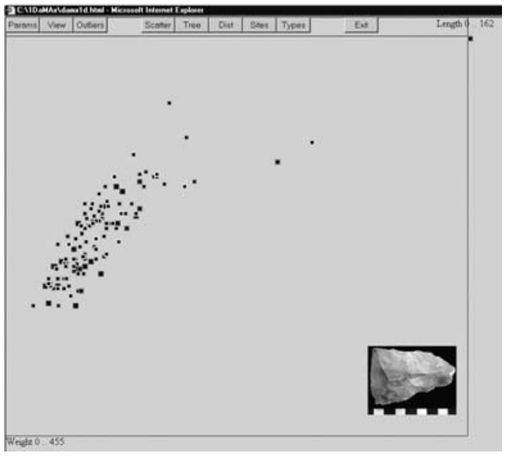


Fig. 5. Cluster diagram: weight vs. length.

6. Using the DAMAXIS System

The first step when using DAMAXIS is creating a cluster diagram. Cluster diagrams are useful for

- Detecting outliers
- Checking correlations between parameters
- Getting an overall view of the available data

One may regard a cluster diagram as the result of a two-dimensional sorting process.

One can select all flake axes, or axes of one site only. It is also possible to enter selection criteria regarding weight and size to limit the output. A separate window is available to choose which parameters should be used in the cluster diagram (see Fig. 4).

The cluster diagram will display, by default, black squares with a coloured rim indicating the site, as each site has its individual colour to enable easy visual inspections (see Fig. 5).

It is also possible to show thumbnail images of the axes directly in the diagram (see Fig. 6).

When you move the mouse over a data point, a summary of the axes' data is shown, and a picture of the axe appears in the low hand side of the diagram. When you click the data point, the axes' summary screen appears. This summary screen can be used to

- assign / change the type of the axe
- make the axe an outlier

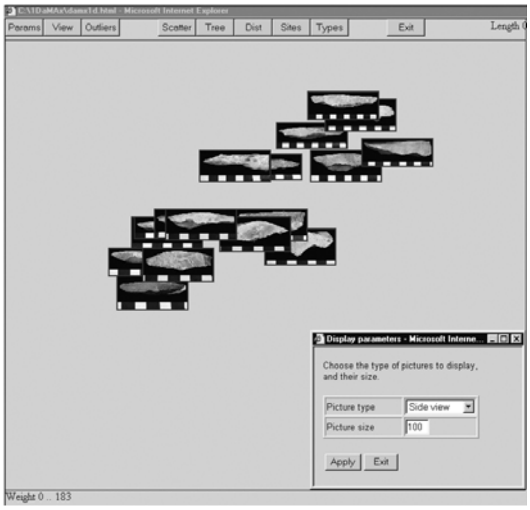


Fig. 6. Display of thumbnail images.

In Fig. 7 an example is given.

In the upper right hand corner of the scatter diagram a dot indicates an axe of 455 grams and 162 mm long. The details screen shows that it is not a flake axe but a core axe, and therefore we apply the 'Mark as outlier' option. This removes the axe from the calculations. There are about 5 axes in the upper right section of the diagram (see Fig. 5) that, on closer inspection, appear to be outliers.

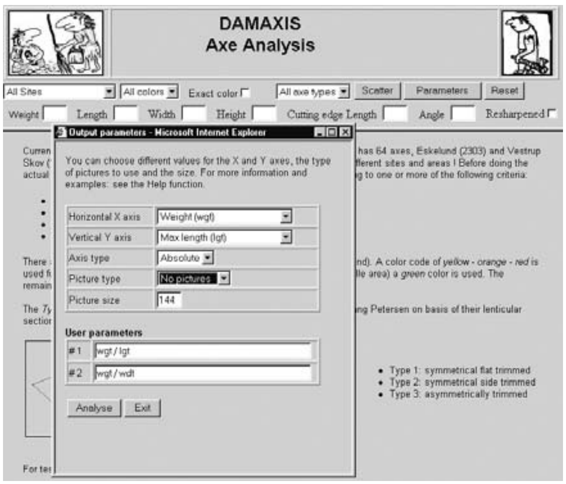


Fig. 4. Choosing X and Y axis for the cluster diagram.

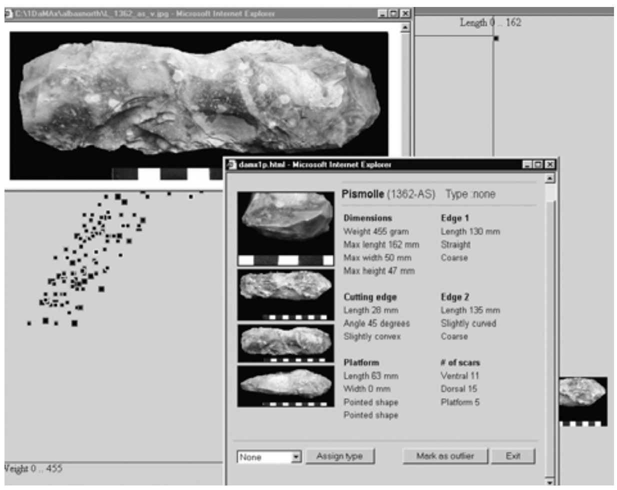


Fig. 7. Detecting an outlier.

7. Tree diagrams

A tree diagram is constructed from nodes and branches. The nodes show up in the diagrams as small black circles. When the system contains N axes, then there are N-1 nodes.
Each node has two branches, the left branch and the right branch. These branches connect the node with either another node, or with an axe data point. So the lowest layer in the diagram consists of data points, connected to a node
The nodes 'inherit' the properties of their constituents: suppose that the weight of axe A = 80, and of B = 120. Then the 'weight' of the node that connects A and B is the average: 100. In other words: the node represents an 'average' axe, based on the axes connected to the node. And the height of the node above its two components is a measure for the distance between its two components.
When the distance between two axes is zero, then the height of the node is also zero, and the node and its two axes are on a horizontal line.
The height of a node can also be interpreted in 'energy' terms: the height is a measure for the amount of energy required to turn axe A into axe B.
When you move the mouse over the nodes (see Fig. 8), the following information is displayed:

- The D(istance) parameter: the higher this value, the higher the node.
- The number of axes in the two branches.
- The parameter values (the average of the axes connected to the node)

When you click a node the screen will refresh and only the node and its components are shown. This is done with the node in the upper right section of Fig. 8, indicated with the arrow. This results in Fig. 9
When you click the top node then you will go up in the tree. This is the mechanism to move up and down the branches of the tree.

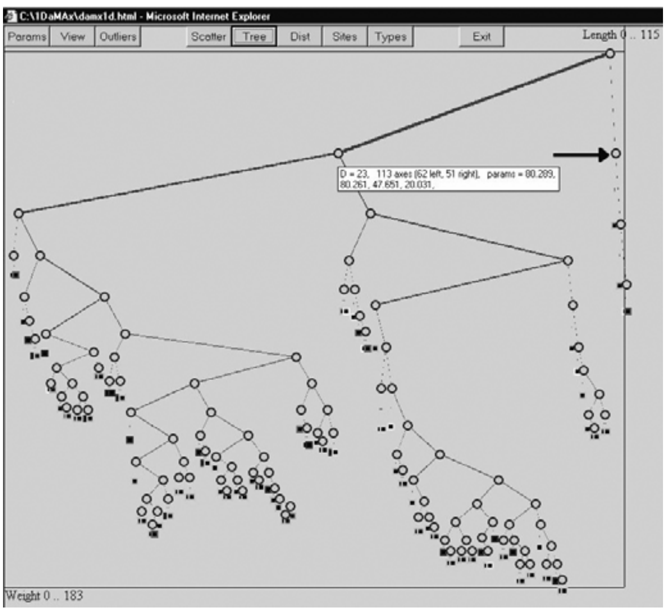


Fig. 8. Node information.

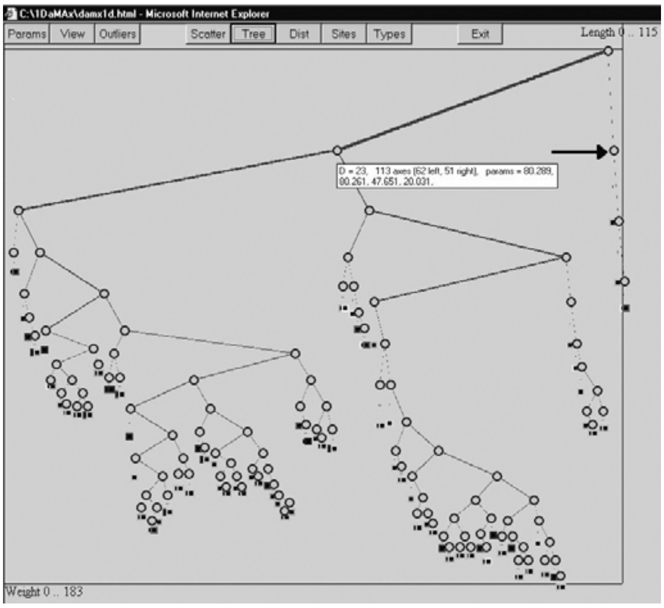


Fig. 9. Moving through the tree diagram.

8. Assigning Types

When the system starts, none of the axes are typed. Different routes can be followed to assign types:

- You can click on individual data points to obtain the axes' detail screen, and assign a type one by one. This method is not recommended when still all objects are not typed, but it is useful in later stages.
- Create a tree diagram and select one of the lower nodes. Next, use the 'Assign types' option. This action is shown in Fig. 9: these four axes will become type 'Green'. This process can be repeated for the other branches. A possible outcome is shown in Fig. 10.

For the different types the average values for the parameters are calculated (see Fig. 11), and images of the axe that fits a type best are shown (the 'archetype' so to speak).

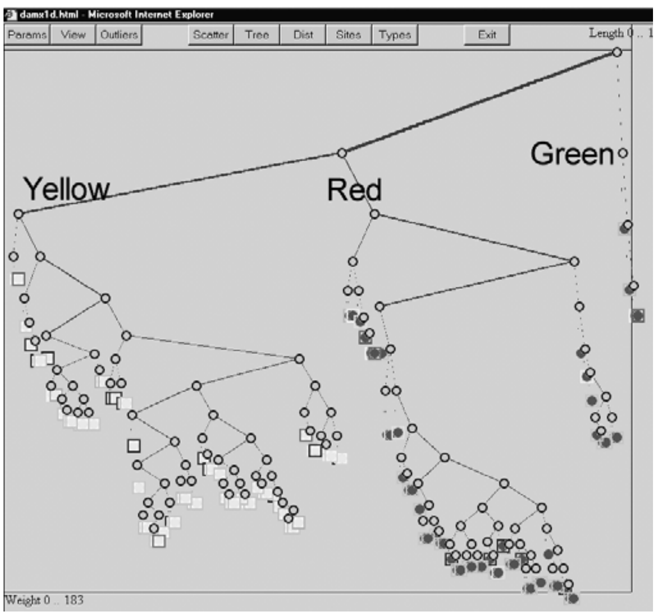


Fig. 10. Assigning types.

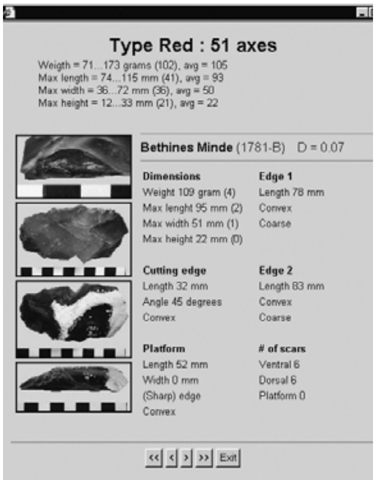


Fig. 11. The archetype.

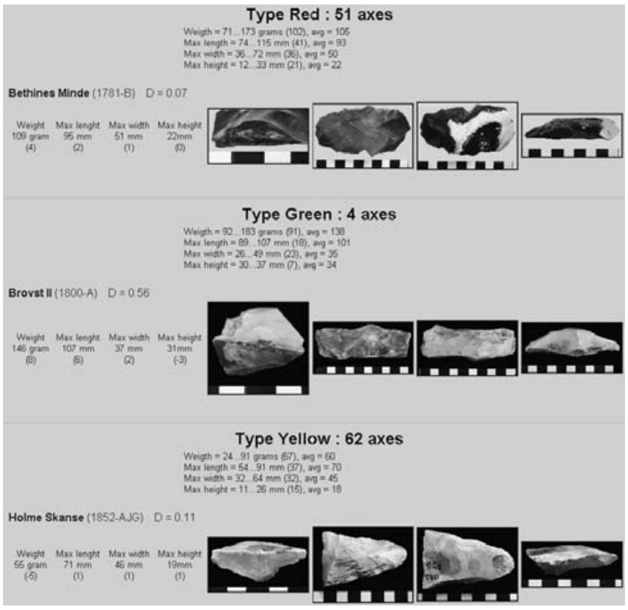


Fig. 12. Comparing types.

The differences between the actual parameter values and the 'archetypal' values are highlighted. The D(istance) value is a measure for the goodness of fit: the lower the value, the better the fit. Push buttons are available to leaf through the complete collection of axes within a type. The axes are sorted on 'goodness of fit'.

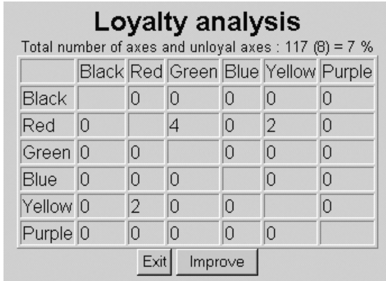
It is also possible to compare the different types. Of each type, images of its archetype are shown, and its details (Fig. 12).

The lowest part of the screen is the so-called 'Loyalty matrix': it shows how many axes of a certain type would rather belong to another type, based on comparisons of the axes with the different archetypes (Fig. 13).

Pushing the 'Improve' button will re-assign the these axes to their preferred type. The result is shown in Fig. 14: several axes that were 'Red' are now 'Green'.

This 'loyalty improvement process' opens the way to a particular interesting way of creating types as follows:

- ALL axes are assigned the same type (e.g. Black)
- Two axes are chosen and assigned another type (e.g. Red). One axe is not enough, because distance calculations require at least two axes per type.



Loyalty analysis

Total number of axes and unloyal axes : 117 (8) = 7 %

	Black	Red	Green	Blue	Yellow	Purple
Black		0	0	0	0	0
Red	0		4	0	2	0
Green	0	0		0	0	0
Blue	0	0	0		0	0
Yellow	0	2	0	0		0
Purple	0	0	0	0	0	

Exit Improve

Fig. 13. The 'Loyalty' matrix.

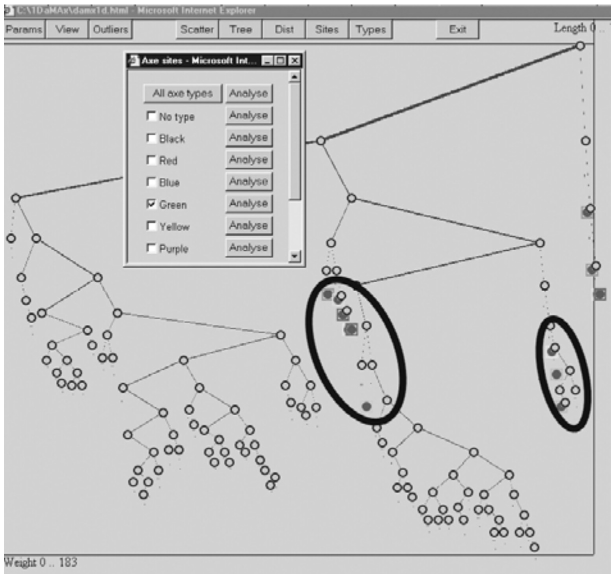


Fig. 14. The result of the loyalty-improvement.

- The Loyalty matrix will indicate that a multitude of Black axes would rather be Red. The 'Improve' option is applied until all axes are sufficiently typed.
- The scatter diagram is refreshed next to see the results.

9. Next

Currently, the set of flake axes is being critically examined to improve the data set. The system itself is also redesigned: the current version is dedicated to flake axes only. The new system is designed for other categories of artefacts also: the parameters will not be hard coded in the program source, but their implementation will be flexible. Currently experiments with data sets of Roman pottery and other prehistoric artefacts (Mesolithic arrow points and middle Palaeolithic Pradnik knives) are envisaged.

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