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The Husbandry of Food Production

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Phil. Trans. R. Soc. Lond. B 1976 **275**, 43-54
doi: 10.1098/rstb.1976.0069

Phil. Trans. R. Soc. Lond. B. **275**, 43–54 (1976)
Printed in Great Britain

The husbandry of food production

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[Plates 1 and 2]

In this paper is it suggested that food production started in different parts of the world without mutual contact. Two main types of husbandry can be observed: (1) cultivation of cereals, e.g. in the Middle East, and (2) cultivation of tubers, e.g. in Tropical Asia and New Guinea. In New Guinea men and women were occupied in different branches of food production while the men also hunted and fished. This type of husbandry can be used as a key to understanding how a complex cultivation system can be carried on with a simple tool-kit.

Digging tools are traced throughout Eurasia and their use explained by imitative experiments. Examples are given to elucidate the transition from the traction spade and the rope-traction ard to the ard-plough proper, and it is suggested that the ox-pulled ard originated somewhere in southeast Europe. But after the introduction of the ard to the Middle East agriculture spread to the foothills and arid soils; the furrows were adapted to irrigation, and soon after the implement was furnished with a seed funnel.

Introduction

According to the most recent evidence, it seems that the husbandry of food production started almost simultaneously in two different parts of the world without any mutual connection: one in the temperate part of the Zagros and Taurus mountains and the other in the tropical part of southeast Asia. The first was dependent on the cultivation of wheats and barley, the other on bananas, sugarcane, pandanus or tubers and probably legumes.

The beginnings of husbandry may have been still more numerous than the two mentioned and others known from the Americas, China and Africa. The development of culture certainly did not follow a simple pattern like the regular waves rising when a stone has been dropped into a pond. Cultural movements should rather be compared with the waves of the open sea, constantly interfering with other waves, never stable, always being transformed into something different. Moreover, cultural traits or innovations can be transported by word of mouth over long distances like wireless telegraphy, and ideas can survive until the conditions are ripe for their success.

Therefore the tools of husbandry could well have been invented or improved repeatedly in different areas and environments, adapted to local shifting conditions and demands. And sometimes improvements may have been lost again when economic conditions changed. One should hesitate to accept such easy and general solutions as the now fashionable 'population pressure' which is believed to be a most active factor in causing alterations and transitions into higher technical stages through the ages. This *deus ex machina* has been introduced into anthropology and archaeology by economists having restricted knowledge of the trends of cultural history. It must be remembered that man was always aware of limiting the factor of natural fertility as well as of hunger, pests and warfare. In a local environment people tried to a certain degree

to adapt themselves to climatic factors and soil conditions, subject to such factors as the possibilities of exchange and marketing, social inheritance and spiritual concepts. Moreover some individuals could migrate to other surroundings, towns or countries.

At present it is fashionable to make speculative calculations about amounts of food production and demands of nutrients in the past. However, one must first try to reveal the mechanisms, interactions, and adaptations in indigenous types of husbandry in all its varieties. It is still difficult to evaluate the consumption of caterpillars in terms of wheat tonnage, or of calorie- or joule-demands.

It is likely that man's inventive capacity was the same in prehistoric times as it is today because his brain had the same structure. But his store of experiences must have been quite different. He was far from 'primitive', his resources were complex and the means and methods by which he exploited them must have been just as sophisticated as those practised by the highlanders of New Guinea in recent times.

Scholars experienced in western urban culture are accustomed to think of systems adapted to a man-made environment in which economy, time tables and demands are regulated in quite a different way from those practised by what they call 'primitive farmers'. For this reason their presuppositions are not naturally adapted to promoting an understanding from the 'inside'. Before the introduction of industrialized equipment farmers were dependent on a wide variety of unforseeable events. Consequently their working programmes had to be altered from day to day, often from one hour to another, adapted to shifting circumstances. And even their tools and implements had to cover a wide range of adaptability, normally not specialized for one single purpose. From the beginning they were rather universal as the straight flint knife used for harvesting grain in the early Neolithic. They only became specialized gradually as one single purpose gained predominance over others. For example the edge of the straight flint knife had to be curved into a sickle shape, according to the growing importance of corn-land (Steensberg 1943).

Therefore the gloss on the edge of a flint knife is no decisive proof of husbandry, any more than the polish of an axe, the existence of a wooden hoe or a digging stick. We are here on unsafe ground regarding the exact time of the domestication of plants and animals. Not even the existence of prehistoric paddle-spades is an unambiguous proof, though some of them were used for the breaking of compact soil. Apparently the paddle-spade was developed from the paddle of the dug-out canoe, used in the same way with the forehand in overgrip and the rear hand in undergrip. The difference between 'digging water' and 'digging soil' is that water tools should be as light as possible whereas tools for the breaking of ground had to be very heavy, made of oak or similar hardwood.

However, prehistoric tools must be studied intensively, even the simplest of them. Marks of wear can be examined under the microscope in order to define the way in which the implement was hafted, utilized or eventually pushed or pulled and what material produced such marks on it. The examination must be supplied by studies under similar circumstances of indigenous people's husbandry in the field or in literature as well as by imitative experiments such as we have performed in the 'Historical and archaeological experiment centre' at Lejre (H. O. Hansen 1969). I am now proceeding to demonstrate this by some examples mostly taken from those on which I have been personally engaged for nearly forty years.

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Digging sticks and paddle-spades

The primary tool for tilling the ground is a stick which must be rather long and heavy in order to break virgin soils. In Indonesia some 3 m long sticks are said to be used in the cultivation of paddy rice fields which are too small or inconvenient for ploughing, and the Old Negritos and Fulbes of Upper-Volta in Africa used a heavy stick almost as high as a man to make holes for the seed (figure 1). These crowbars are different from the small digging sticks used by women when collecting roots and tubers. The hoe was mostly used for weeding, and predominantly by women (Dittmer 1958). In 1953 Erika Purse-Stanek reported from Taiwan that a chipped stone was still used as a hoe in fields of shifting cultivation, and in Timor, Ian Glover found digging sticks equipped by a celt shaped tip of iron. Some of our prehistoric celts may well have served similar purposes.

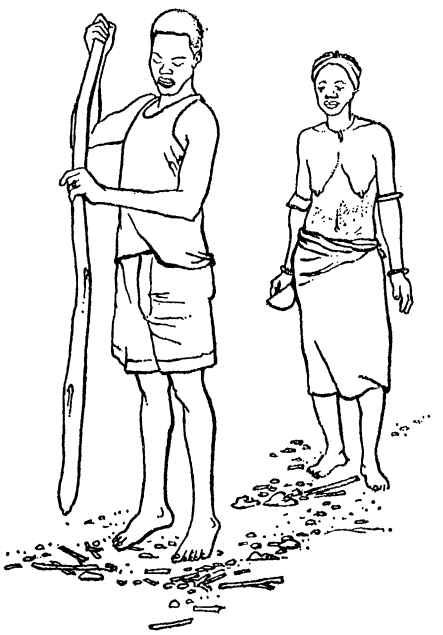

Figure 1. In Upper Volta, West Africa, the Old Negritos and Fulbes used a heavy stick to make holes for the seed. This was shaped like a paddle in its lower end (after Dittmer 1958, p. 433).

However, according to Kunz Dittmer, the heavy stick by the people of Upper Volta was flattened like a paddle, and paddle-spades have been widely distributed in the ancient world. In prehistoric times they were manufactured in the Ural region since the 3rd–2nd millenium B.C., and they were used in the Altaj and the Ukraine in the middle of the 1st millenium B.C. according to Professor B. A. Šramko. In the 1st millenium B.C. shovels of this type were used at Kvikne in Norway, dated to 400 and 230 B.C. In modern times K. Birket-Smith found such shovels in use by the Bontoc Igorots at Luzon, and in Mustiala Agricultural Museum, Finland, rather short specimens, elegantly manufactured, can be studied, used in potato fields until the end of the 19th century. Even in New Zealand this rather universally known digging tool was in normal use by the Maoris.

Several thousands of years may have passed before husbandry was fully established, and I believe that for a long period different members of the same family were employed in different parts of the processes of food-gathering and food-production, similar to the complemen-

tary symbiosis of groups of hunter-gatherers, nomads and agriculturalists. In New Guinea and elsewhere one can observe this division of labour, predominantly between the two sexes, the men hunting and breaking new ground the women gathering and tilling small permanent fields, and both sexes taking part in the one or two years of shifting cultivation in the swidden field. These societies, until recently using 'stone-age equipment', are probably the nearest we can come to a living model of incipient husbandry. At Kuk in the New Guinea Highlands Jack Golson found a system of drainage ditches which could be dated to 3000–4000 B.C., and a 4 m wide canal now is safely identified as man made, dated to 7000 B.C. The cultivation of taro must have been practised for at least 5000–6000 years, and cultivation of other crops 9000 years ago. Probably it is even older in the tropical part of Asia. About 1500 years ago 'the New Guineans evolved a very fine system of drains which achieved the critical balance necessary to cope with the huge amounts of water that flow through the valley' according to Golson (1975).

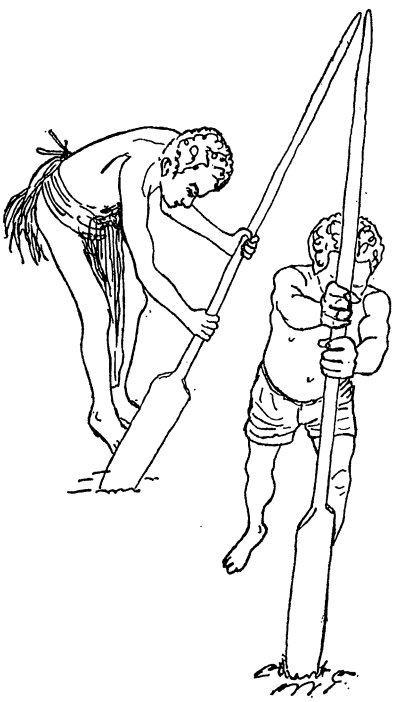

FIGURE 2. A man in Menzim, The New Guinea Highlands, starts digging a ditch with a long fossile paddle spade, found in one of the ancient canals in the neighbourhood, and another man opens the grassy ground near Banga in the same district with the same implement (Steensberg's drawing).

The digging tools of New Guinea can be divided into three groups. (1) Long, heavy spades which are often buried in a water-ditch when not in use in order that they may keep heavy by soaking up water and also to avoid cracks in the wood. Such means have also been practised in summer time in Northern Europe when wheels and barrels were on the point of falling to pieces. Obviously not all tools and utensils found in bogs and swamps from prehistoric times were placed there for religious purposes. (2) Short paddle-shaped spades, similar to the New Zealand 'kahero', but never furnished with an angled handle. (3) Digging sticks pointed at one end for uprooting tubers from the beds and mounds. The last two types can be combined in one for ceremonial use (Lerche & Steensberg 1973).

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When a man starts digging in compact grassy ground he grasps the heavy spade quite near the blade with his right hand in overgrip and his left hand a little below the middle of the shaft in undergrip, presuming he is right handed, and pushes the tool obliquely into the soil surface (figure 2). When he has broken the grass-sod and made a hole and cleared the loose earth away, he starts making a real trench, cutting straight sides with the edge of the blade. In the tropical highland it is necessary to make trenches around the houses, but drainage trenches are also dug around the beds grown with root crops, just as in prehistoric times. In fact the way men grasp their spades is similar to the handling of a European trenching spade, but people sometimes are seen shovelling with a modern steel spade in the same way, even if it would be more convenient to use the fore-hand in undergrip. One should always notice the way indigenous people handle their tools, because such traditions may reveal important traits in their household economy and husbandry. Another important trait is the balance of a tool. Therefore a blade may tell very little without its shaft, and an edge must always be studied in connection with its hafting angle, etc.

The short paddle-spade is used for recultivating sweet-potato beds after 2–3 years of fallow. The right hand is normally in overgrip with both hands moving up and down the shaft according to the effect intended. Sometimes the clods are pulverized by beating the spade into the mound, sometimes one uses the edge, and sometimes the flat side of the blade, as Grith Lerche and I have described in detail in *Tools and tillage* (1973). Now and then the cultivator simply uses his fingers to scoop the soil up the sides or to clear away roots and weeds or to crush lumps of earth. And when digging deep trenches the worker will use his tool as a shovel or an assistant may remove the loose soil with his hands, forming a natural shovel.

The digging stick is used for harvesting sweet-potatoes, digging up wild roots, etc. Often the woman will use both hands but sometimes one hand only according to the effect she wants to achieve. The left hand is always used in undergrip, the right hand normally in overgrip, when taking potatoes out of the bed.

Incipient agriculture

It has been suggested that agriculture started in the tropical rain forests as complex cultivation and later developed to specialized monocultures (Harris 1972). This may be true in some regions. But I believe that in New Guinea monocultures have existed side by side with more complex cultures from the early beginning of agriculture as it is today. The drained beds, found by Jack Golson when excavating the swamp at Kuk tea research station, were presumably planted with taro. But swiddens may have existed in the surrounding area at the same time, leaving no visible traces on the surface; they may have been planted with yam and a mixture of other species. Of course the technique of felling trees and shrubs and burning the timber and branches afterwards was originally meant to produce open areas with grass and fresh sprouting bushes in order to attract game for hunting long before man began to till the soil or keep cattle and pigs for his household (Steensberg 1955). However, the earliest domestication of cattle seems to have been in the Balkans, not in the tropics (Higgs 1972), and the early domestication of cereal crops did not happen in the tropics either.

Most of the wild vegetation such as berries, fruits, shoots of perennials, sugar canes, etc., had the disadvantage that they could not be stored very long. Roots and cereals were more profitable in this respect. Therefore these elements would be a useful addition to the products of gathering

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and hunting. Tubers were cooked in pits in the soil, as we observed in the New Guinea Highlands, and in drier climates cereals could be stored even longer and prepared by grinding in mortars for soup whenever other kinds of food became scarce.

As far as we know at present, corn growing did not start in the arid region at the foothills of the Taurus and Zagros mountains, but in the temperate highlands, where shrubs and timber were easy to burn and where a comparatively strong winter prevented gathering of vegetables for some months. Why should this kind of cultivation be complex? Wheats and barley were apparently grown in separate fields. But in addition men would presumably make swiddens outside the home-gardens. This was what I meant by 'symbiosis' in my introductory remarks.

In Satrup Moor in Angel, Schleswig, some tools were found belonging to the transition phase between the Ertebölle Culture and the Neolithic (in calibrated terms of dating about 4200 B.C.). One of them is shown in figure 3, and the blades of the three most complete items are shown in figure 4, plate 1. The first mentioned was a 187 cm long 'rope-traction ard', shaped like a spade with a triangular blade, carved out of an ash trunk in one piece with the shaft. Two grips for the hands were made by a burning stick, and these marks proved exactly how the tool was used (figure 5, plate 1). Moreover two perforations near the upper border of the blade demonstrate that is was pulled by strings. Imitative experiments with an exact replica has proved that it is adapted to loose soil, and that it covers sown seed completely (figure 6, plate 2) (Steensberg 1973). Moreover when the seed has been sown in rows the cultivators, supposedly women, could walk between the rows weeding the cultivated plot. This is certainly proof of a very intensive cultivation, which can be compared with the 'horticulture' of the New Guinean Highlands.

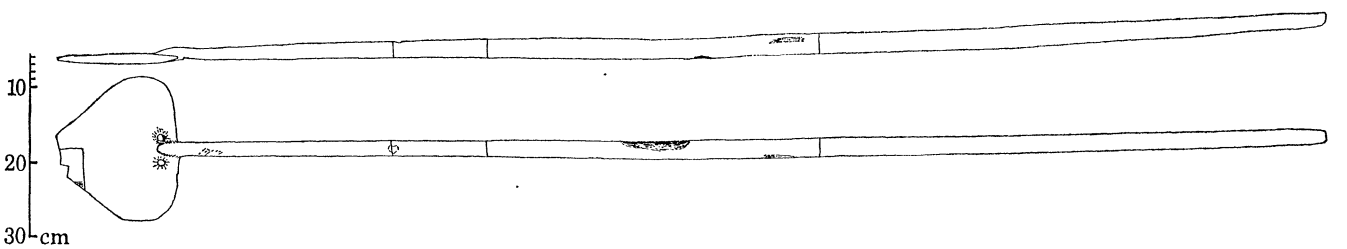

FIGURE 3. A rope-traction ard found in Satrup Moor, Angel in Schleswig, and dated to *ca.* 4200 B.C. in calibrated terms. The tip has been broken off. Two holes for pulling ropes in the blade and grips for the hands on the shaft can be seen (Steensberg's drawings).

Apparently this tool was the forerunner of the ard pulled by oxen, but the Satrup implement was probably pulled by a woman. In Hama, Syria, similar tools were found (i.e. the blades of them), made of either basalt or a compact, hard limestone (Steensberg 1964). From wear marks on the surface I could deduce that they had been mounted with a long shaft and pulled continuously through the soil, just as the Satrup specimen. However, these tools from Hama were dated to the Bronze Age between 2400 and 1800 B.C., and they existed side by side with an ard, mounted with another share of basalt, the wear marks of which proved that it could only fit to the local ard-type. But while the Satrup specimen would produce a furrow of from 5 to 6 cm depth, the Hama copy produced a furrow of about 10 cm depth, adapted to the drier climate of this region. While the Bronze Age people of Hama had the ard-plough proper for initial tilling after fallow, the people of Satrup must have broken the ground either with a long digging stick, like those described from Indonesia, or by a heavy paddle spade like those

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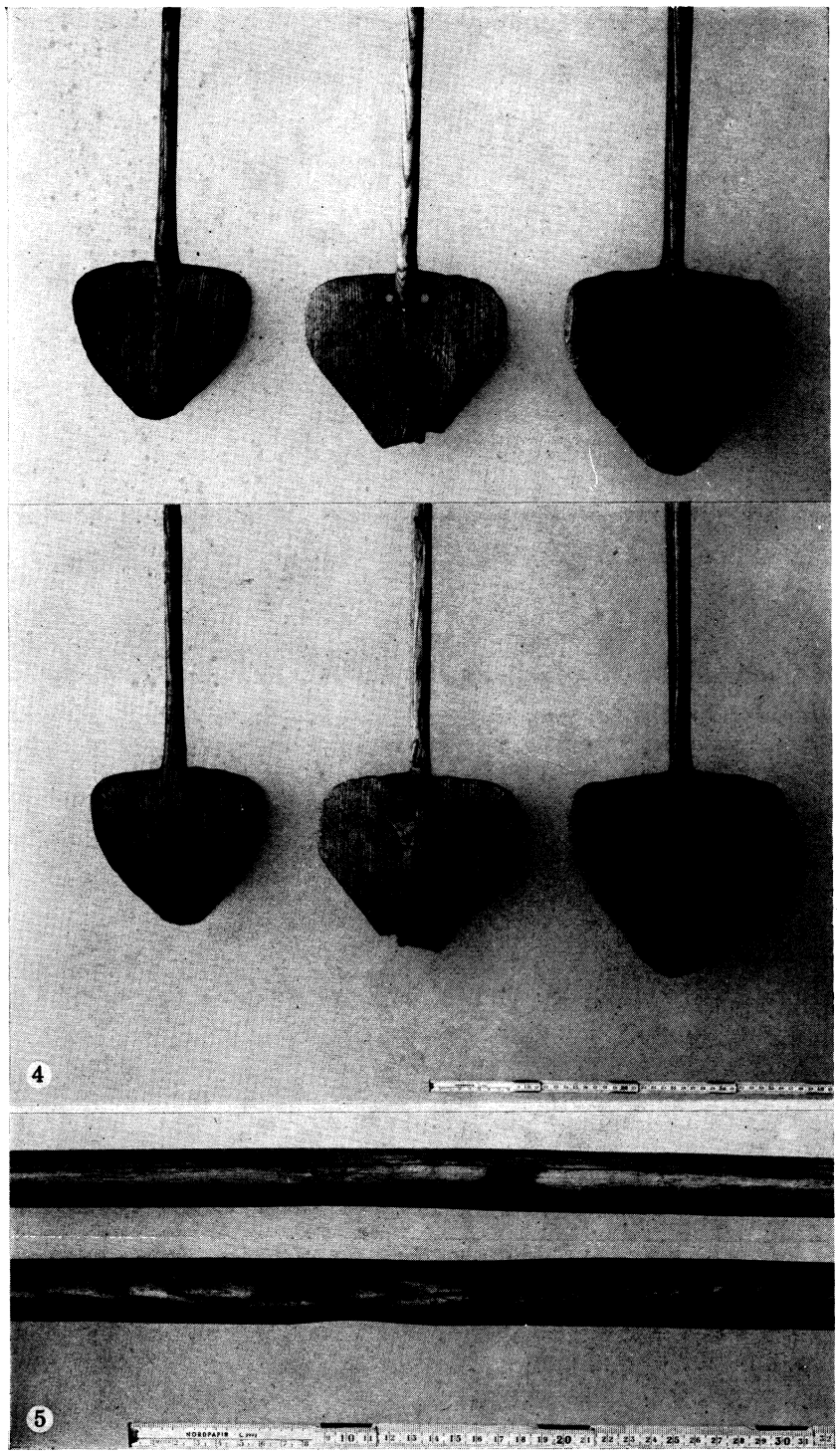

FIGURE 4. Three of the Satrup-implements shown from the front (above) and behind (below). On the rope-traction ard in the middle striations from the flint-blade are visible. The two other specimens are believed to be shovels, eventually used for winnowing grain (photograph by Elswing).

FIGURE 5. Handgrips produced by a burning stick in the shafts of two of the Satrup specimens. Above the rope-traction ard, below the complete shovel (photograph by Elswing).

(*Facing p.* 48)

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FIGURE 6. Ploughing with a replica of the rope-traction ard from Satrup Moor. It will cover seed sown in the previously opened furrow effectively (after Lerche & Steensberg 1973).

FIGURE 7. A man-pulled traction spade or ard used in a paddy field, Kweichow, China. The man controlling the implement with his left hand helps the man pulling in front by pushing the yoke carried on their shoulders (after Chang-Kong Chiu 1937, fig. 47).

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found in different parts of Eurasia from prehistoric times. One can hope that such tools may be identified in bogs and swamps of Northern Europe in the future. In Åmosen, Zealand, some pieces, which were originally thought to be paddles, may well on closer observation prove to have been used for tilling. At the moment Grith Lerche is carrying on a study of spades from the Iron Age of Jutland, a field of research which has hitherto been neglected.

The ard-plough

The earliest find of the ard-plough itself in Europe seems to be the Hvorslev ard from a bog in Jutland, dated to *ca.* 1500 B.C. (*Tools and Tillage* 1968). However, the traces of ard ploughing can be dated much earlier. In Sarnowo, Poland, such furrows have been found belonging to the Funnel-Necked Beaker culture, dated to 3620 ± 60 B.C. in ordinary radiocarbon terms. But in Denmark they were only found from the Passage Grave period, and never in connection with the earliest Neolithic.

J. Troels-Smith did not find traces of slash-and-burn husbandry in the incipient agriculture, either in Denmark or in Switzerland. He thinks that the men were still occupied with hunting and fishing as in early Ertebölle time, while the women gathered fodder for the cattle which they kept home at the settlement. And they grew wheat and barley in small intensively tilled plots as a kind of 'horticulture', while the slash-and-burn culture started later on with what J. Iversen called the 'Landnam'.

However, there may have been different variations in incipient agriculture in different parts of the Ancient World adapted to different conditions of climate, vegetation and soils. It is tempting to assume that corn-growing was invented by women who were accustomed to gathering wild cereals, and that cultivation started in swiddens made for the attraction of game as small beds, intensively tilled and hedged like garden beds. It could well have been a mixed system where the men sometimes cleared new areas for swiddens, which would produce a tolerable crop in addition to hunting and fishing, while the women tilled their small plots intensively between whiles gathering wild plants and berries, etc. Future research should concentrate on investigations similar to those carried out by Troels-Smith and his team in Danish and Swiss bogs.

In Babylonia the first picture of an ard-plough belongs to the Uruk phase *ca.* 3000 B.C. And it was soon fitted with a seed-funnel because of the arid climate and probably in connection with irrigation of the fields. At Kalibangan, North-Western India, ard-furrows were uncovered below layers of the Pre-Harappa culture, *ca.* 2450–2300 B.C. 5 cm broad furrows were made at a distance of *ca.* 30 cm in east–west, and at every 190 cm they were crossed by other furrows. The closely spaced furrows were ploughed first. In modern times the same pattern can be observed, the closely spaced furrows sown with horse-gram, the crossing ones with mustard. The horse-gram is short, the mustard tall. Sir Joseph Hutchinson has told me, that it is customary to sow winter cereals – wheat or barley – in the closer rows, or in some cases pulse. The crossing rows are then sown with a Brassica oilseed. Irrigation is normally practised, dividing the field into small plots, each of which is flooded from one side or one corner, and the water is then raised from wells, from 10 to 50 m deep, with oxen or camels. In modern times the ard is often pulled by a camel.

Presumably such traces of early ploughing could be found elsewhere below the tells of the Middle East if archaeologists refrained from digging in sections. It is to be hoped that someone

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will follow the success from Kalibangan, by uncovering greater areas and spending as much money as is necessary.

The question arises when and where farmers started ploughing with an ard pulled by oxen? In Asia rope traction of spades is a wide-spread fashion, and the tool from Satrup seems to indicate that at an early stage of farming this was also practised in some parts of Europe, though the custom was later on abandoned. The common way of traction was to stick the spade into the ground and pull it up, moving sidewards after each row, not a continuous forward movement as by ploughing.

Ancient Chinese tilling practices

In China the transition from spading practice to forward ploughing with a man-pulled ard is testified by two drawings from the Kweichow province in South China. One of them (figure 7, plate 2) is from a manuscript in the Library of the Duke of Gotha, Germany, with the title (translated): 'The Album of Mao-Man carefully drawn and furnished with texts, by a famous man', probably from the late 17th or early 18th century. It is supposed to demonstrate a traction spade used in a paddy-bed because a woman to the right is planting rice from a bundle under her arm. The spade is pulled by the man in front, partly by his left hand grasping a rope, and partly by a yoke which he bears on his right hand and shoulders. The other person carries the rear end of the yoke on his right shoulder, pushing it forward. The centre of the yoke is connected by another rope with a crossbar, tied to the shaft of the spade rather near its blade, so that the implement can be pulled forward and upward while the man behind is steering the spade by aid of a rather long handle, fitted horizontally to the shaft like a plough-handle. The question is, whether this implement is pulled continuously through the muddy soil or whether it is pressed down and lifted up as a normal traction spade? However, the man controlling the handle of the implement seems rather to lift it than to press it down. And if he did press it down, why not grasp the handle as near as possible to the shaft in order not to break it? It has been suggested that the crossbar might be used as a foot rest, but obviously as it is only connected to the shaft of the spade by a knot and string, it could hardly have been used as a foot rest.

The other implement (figure 8) is even more akin to an ordinary ard-plough because it is fitted with a beam made of wood. Moreover the Chinese text indicates that it is a ploughing implement. The crossbar is mortised to the front of the beam from which the strings goes up to the yoke, carried by both the controller and the puller. It has been suggested that the controller was pressing the implement with his left foot, but if so one would expect to observe his toes in the opening behind the prolongation of the share. Apparently his left foot is totally hidden behind the sole of the implement. The most convincing proof that the implement is a real man-pulled ard is that it is furnished with a distinct sole and that the soil seems to be ploughed up in front of its share. Heinz Kothe compares it with an Ainu woman pushing her 'Cashrom'-like tilling spade with her left foot moving backwards bit by bit. But the man-pulled ard is definitely pushed forward. However, Professor Kothe has drawn attention to the fact that the oldest Chinese character for plough originally must have illustrated some kind of hand tool which could either have been of the 'Cashrom'-type or been pulled forward continuously like the rope-traction ards of Satrup Moor and Hama or the implement on figure 8. I would suggest the latter explanation as the more likely.

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In the northern part of China there is an old tradition of sowing in drills – as also in Deccan, India, in more recent times. For example this was the traditional way of dry-farming in the 6th century A.D., as we learn from 'Ch'i-min yao shu', the ten volumes of Chinese husbandry written by Chia Ssu-hsieh in Chin-tou, Shantung, 533–540 A.D. (translated into Japanese by Kumashiro & Nishiyawa 1969, in two volumes, the second comprising the commentaries). In this book is described a type of seed-drill the body of which could be transformed into a horse-hoeing implement, and which could have one, two, or three pipes or shares. We are told that in spring the seed should be covered deeply, but that in summer it should have a shallow covering

FIGURE 8. A man-pulled ard-plough from the Ch'ing-Miao, Kweichow in China. The man controlling the ard helps the man in front by pushing the yoke which they both bear upon their shoulders (after Kothe 1958, fig. 3).

because in spring the atmospheric temperature is low and germination slow, whereas in summer it is otherwise, and if a shower comes, the seed will sprout immediately. 'In general (the) effect of the sowing with the Chinese wooden drill is not only rapid germination, because of its relatively shallow seeding, but also that thereafter the hand hoeing and sharp-spading are easily done' (vol. III, 3, on German millet, p. xvi and 10, barley and wheat, p. xvi). Apparently the seed was sown between ridges, because we are told that when the young plants had grown so high that they were just above the level of the ridges, one might change from the ordinary hoe to the hand-hoe. This practice would go on repeatedly all around the fields, the aim being not only to cut the weeds, but also to produce a good tilth.

It is more astonishing, that when the young plants had risen above the level of ridges, and since after every rainfall the soil would form a dry crust, one had to cross-harrow with the iron-toothed harrow and afterwards with the knot-harrow (a sort of net with knots at the junctions). In using the iron-toothed harrow a man sat upon it and cleaned the teeth for weeds in order that the harrow-teeth should not tear up the young green plants. Lastly when the plants had reached a height of *ca.* 30 cm the soil should be cultivated by using a sharp spade and this would be repeated three times (vol. IV, 3, German millet). The author continues: 'The aim of hand hoeing in the spring is to stir the soil surface, and in summer to cut the weeds. Therefore hand hoeing in the spring should not be done when the soil is too wet; but after the month of

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July the wet hoeing will be harmless. Since in the spring the plants are yet young and the shade they provide is small, wet hoeing lets the land bake into a hard mass. In the summer plants already give a lot of shade and prevent undue evaporation, so that the very wet hoeing may be harmless' (vol. IV, 3).

From these extracts of 'Ch'i-min yao shu' we learn that though the tools for tilling were rather primitive the culture itself was most sophisticated. Why should this not have been the case in Neolithic times also? We are looking forward to an English translation of his most valuable book of husbandry, which Miss Franscesca Bray is preparing in Cambridge. Its standard is just as high as the not much older classical Roman works.

The oxteam

In the 6th century the rope-traction ard or in China hoe could be pulled by a horse. And from time immemorial the fashion of pulling spades or hoes by man-power must have been practised in Asia and Europe. But where did man first harness a pair of oxen to the ard-plough? From our present experiences it is most likely to have happened in the Balkans because from here we have the first indications of domestication of oxen (Higgs 1972), and they may originally have been tamed as draught oxen? Europe has always been exposed to Atlantic wind and in the deciduous woods – either in the mountainous South-East or in the North-Western lowlands – there would be a suitable vegetation for cattle-breeding as well as for wild species. The traces of ploughing at Sarnowo in Poland mentioned above are much older than traces of ploughing in the Middle East, and we ought to concentrate research into this subject on the Balkans and the Carpathian Region.

The ox-pulled ard-plough must have been used on extensively exploited areas outside the intensively cultivated beds around the human sites, probably in connection with an outfield system. When commons were tilled regularly in a rotation of 15–20 years in recent time in Northern Europe, the swiddens would not be so entangled by roots that an ard-plough could not be used. Even in the virgin coniferous woods of Finland and Northern Russia an ard with a beam rather high elevated over the ground and with a vertical stilt could cover broadcast seed efficiently. Most of the traces of ploughing which can now be observed in the subsoil seem to be produced with an ard of the so called 'Döstrup-type' with a rather pointed and steep share, while the Mediterranean 'Triptolemos-ard' with its rather horizontal and long sole would produce less discernible traces in the subsoil. In the Middle East the ox-pulled ard of this type seems predominantly to have been used for covering the seed. When cultivation spread from the higher areas with more rainfall to lower and drier regions a seed funnel was soon added to the ard, and irrigation came into practice.

The effect of shifting cultivation

In this paper I have not examined the techniques of cutting trees with stone axes and the burning of the dried vegetation in shifting cultivation, but an experiment carried out in Draved Wood in Jutland during the years 1953–55 will soon be published. Only two provisional publications of this experiment have so far been written in English by Johannes Iversen and the present author. And a more comprehensive paper on shifting cultivation based on written material from the time of the Roman writers on husbandry until today has only been published

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in Danish with a summary in English (Steensberg 1955). However, one should consider the effect of fire on the soil which Nye and Greenland examined for the tropical Africa, and which has been extensively treated in a 'Bibliography on effect of burning on soil properties', put together for the Commonwealth Bureau of Soils, January 1959, with short summaries of research. From this we learn, that the effects of burning are threefold: '(1) Large quantities of nutrient ions from standing vegetation and the litter layer are spread in the ash on the surface of soil in the form of carbonates, phosphates, and silicates of the cations. Nearly all the nitrogen is, however, lost to the atmosphere as ammonia, gaseous nitrogen or the oxides of nitrogen, and sulphur dioxide. (2) The immediate soil surface is heated, and this has some direct effect on the microbiological population, on the physical and chemical properties of the soil colloids, and on the availability of nutrient ions. (3) The change in pH and nutrient availability may cause a very different microflora from that originally present to develop' (Nye & Greenland 1960).

Concerning the burning of woods, all published data indicate a considerable increase of available cations in the soil and consequently an increase in the pH. And according to Nye & Greenland it has not been proved that burning destroys some of the humus stored in the soil. Only the non-humus material lying on the surface seems to be burned. The effect of burning on the soil itself releases such rich nutrient that this type of husbandry had been profitable side by side with the permanent and intensively tilled areas around human settlements during several thousands of years. Therefore more imitative experiments on this subject ought to be performed especially in the deciduous woods of Northern Europe.

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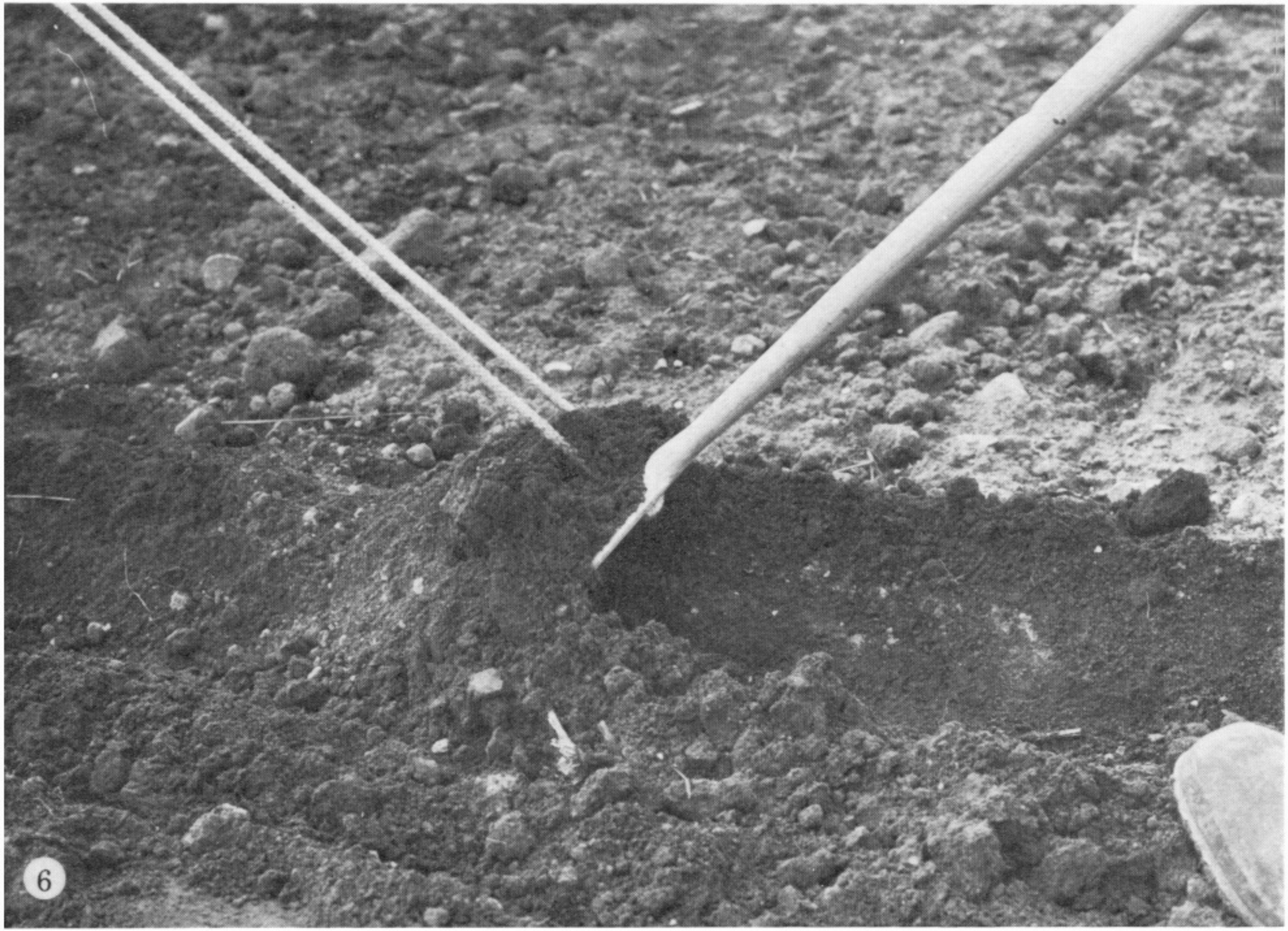
FIGURE 4. Three of the Satrup-implements shown from the front (above) and behind (below). On the rope-traction ard in the middle striations from the flint-blade are visible. The two other specimens are believed to be shovels, eventually used for winnowing grain (photograph by Elswing).

FIGURE 5. Handgrips produced by a burning stick in the shafts of two of the Satrup specimens. Above the rope-traction ard, below the complete shovel (photograph by Elswing).



IGURE 6. Ploughing with a replica of the rope-traction ard from Satrup Moor. It will cover seed sown in the previously opened furrow effectively (after Lerche & Steensberg 1973).

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GURE 7. A man-pulled traction spade or ard used in a paddy field, Kweichow, China. The man controlling the implement with his left hand helps the man pulling in front by pushing the yoke carried on their shoulders (after Chang-Kong Chiu 1937, fig. 47).

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