THE HISTORY AND DEVELOPMENT OF THE HOHENHEIM SYSTEM OF PASTURE MANAGEMENT

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Early Development

The Hohenheim System of Pasture Management originated near Hohenheim, Germany, at the Hohenheim Experiment Station. The Hohenheim Station is situated on high ground, about 1200 feet above sea level, some six miles from Stuttgart, and includes about 1,000 acres.

Dr. Warmbold was head of the Hohenheim Experiment Station for two and a half years during the World War. Later he became Minister of Agriculture for Prussia. It was during his term at the college that he perfected the Hohenheim system of grassland culture for the production of large quantities of nutritious grass. This system is attracting the attention of agricultural authorities and practical farmers throughout the world today.

The history of grassland management probably dates back to the time when men got their living principally by raising animals which they had domesticated. These are the herdsmen that followed the sun by day and the stars by night, continually moving their animals to fresh pasture. In their travels they came onto places which were more productive than others and soon colonization set in about these more productive areas. Eventually they found that certain plants were more useful for forage than others, and that these plants could be increased by waging war against the less useful ones. Here was

the beginning of agriculture, as we know it today, and as population increased it became necessary to practice intensive methods of agriculture.

The scarcity of food reached its height during the World War when Germany, cut off from the outside world, had to rely on its limited area of land and the energy of its agriculturists to supply food and raw material for its large population, including a great fighting army.

War uses up tremendous quantities of nitrogenous compounds. If it had not been for the invention of processes to fix the free nitrogen of the air by Haber, Ostwald and others of Germany's great chemists, the war would have ended early in 1916(8), not only from the exhaustion of nitrates for explosives, but also from the exhaustion of her food supplies as a consequence of the lack of nitrate and ammonia fertilizer for her fields. The fourteen large plants, for the fixation of nitrogen, erected during the war made Germany independent of the world for nitrogen. These plants can fix 500,000 tons of nitrogen a year, which is more than twice the amount needed for internal consumption. The German government with large quantities of nitrogen on hand set out to use a portion of this nitrogen, not needed for explosives, to make her independent of the world for food.

During the year 1916, the German government appealed to Dr. Warmbold, then head of the Hohenheim Agricultural College, to find a method to increase the producing power of Germany's agricultural land. Being well versed on grassland culture, he hit upon the idea of increasing the output of grass-

land as a most efficient means of increasing the producing power of Germany's land, and in turn make the most efficient use of the quantities of nitrogen fertilizer on hand. During the year 1916, Dr. Warmbold, through the application of a combination of grassland principles, evolved a system which was destined to treble the producing power of Germany's already quite productive grassland. His scheme of pasture management is known to us as the Hohenheim System of Pasture Management, named after its place of origin.

An excellent description of the set-up of Dr. Warmbold's experiment is described in the Journal of the Ministry of Agriculture(6) for 1926 as follows:

"In the spring of 1916 about sixty nine acres of pasture were divided into ten enclosures of from four to ten acres each; two strands of barbed wire and posts at three yard intervals being used as fences. After ten years these fences are still intact. A plentiful supply of running water was diverted so as to serve two adjacent fields in turn.

"Up to 1916 an area of 1.4 acres was required for the maintenance of one cow of 1,000 pounds weight from the end of April to the beginning of October. From the winter of 1916-1917 onwards the pastures have been manured with 107 pounds per acre per annum of pure nitrogen besides phosphate and potash. At the beginning of the treatment, 36 pounds of phosphoric acid (P_2O_5) and 80 pounds of potash (K_2O) were applied per acre. In the following years the phosphorus and potash were reduced but the nitrogen remained the same.

"The phosphates and potash were applied in the

autumn. One half of the nitrogen dressing in the form of sulphate of ammonia is given about February 1st and the other half in three separate applications, usually as urea, in May, June, and July. For summer applications urea seems to have special advantages not yet understood. Lime at the rate of 900 pounds per acre is applied at intervals of six years.

"The effects of this heavy manuring was seen in 1917, when an area of 3/4 of an acre was sufficient for one cow. From 1918 onwards 1/2 acre per cow was sufficient.

"During Dr. Warmbold's term 69 acres carried from April to October 56 cows and 20 store stock and of this area 38 acres were cut for hay in May and June. In 1918 the average yield of milk per acre was 445 gallons, and this was obtained from the dun and white German breeds, which are kept primarily for drought purposes.

"In order to secure the full nutritive capacity of a pasture the grass must be utilized in its leaf stage. Under this system of manuring the grass starts earlier in the spring, and therefore must be stocked earlier. If the head stock is insufficient to keep down the vigorous growth, part of the pasture should be cut for hay. The large number of enclosures which can be grazed are mowed according to circumstances.

"The first bit of each enclosure is reserved for the best milking cows. After two or three days on a plot these are followed by lower yielding cows, or by dry cows and store cattle. This sequence is followed around the whole series, provision being made for each plot to have ten to

twelve days rest without stock of any kind.

"At the date of the visit the 69 acres were carrying 56 cows in milk, of the Allgauer Braunvich breed, followed by 7 dry cows and 4 horses. Three enclosures had been cut for hay. It was, however, evident that the plots had gotten out of hand and that at least 50% more stock could have been carried.

"Circumstances during 1926 prevented the carrying out of Dr. Warmbold's scheme in its entirity. Nevertheless the plots were intensely interesting. The soil is Keuper marl, heavy and sticky under arable conditions, and the average rainfall is about 20 inches. The predominant grass is perennial rye grass. Other grasses well represented are cocks foot and rough-stalked meadow grass and occasional plants of meadow fescue, timothy and crested dogstail are also seen. Weeds, such as bent and Yorkshire fog are rare.

"All over there is a liberal distribution of sturdy, vigorous white clover, It is perfectly clear that this system of manuring combined with grazing and mowing, is not detrimental to white clover. The early spring grazing keeps the grasses in check, the occasional mowing mitigates the smothering effect of luxuriant grasses, and the heavy treading tends to reinforce a combination well suited to the development of white clover.

"Doubts have been expressed as to how far the results obtained by Dr. Warmbold were due to improved methods of pasture management, and how far, if at all, to nitrogenous manuring. The most skeptical, however, after seeing Dr. Warm-

bold's plots, would be convinced that no system of management which omitted the use of nitrogenous manures could produce such luxurient herbage as that at Hohenheim; and the effect cannot be attributed to manurial residues of feeding stuffs, because no cake or corn is fed to the cows in summer, whatever the yield of milk may be. The herd at the moment includes 1,000 gallon cows and several cows giving four to five gallons a day, and there is no indication of any need for "production" rations. The whole herd was in remarkable fresh and vigorous condition.

"For making hay out of season, and also for making clover hay in the ordinary course, the Germans adopt a method of drying in "huts". Three poles are fastened together at the top by a wire and erected in a tripod. Brace pieces of wood are then fastened to the poles, and on these the partially made hay is piled in the form of a cock. It is maintained that hay dried in this way has a feeding value equal to that produced by sun and wind as rain passes through the hay quickly and does not wash out the food constituents.

"Perhaps an even greater difficulty is the fouling of the pasture by the close stocking. As the stock are moved on it is necessary to spread their droppings, and in a dry spell the smearing caused by the harrow will not be obliterated so long as dry weather lasts. At Hohenheim the droppings were collected by a shovel and distributed in winter."

From these few paragraphs it is conclusively shown that Dr. Warmbold's success was chiefly due to the scientific use of fertilizers, and in particular the use of nitrogen. The Germans contend that only by a right apportion-

ment of manurial ingredients can normal,healthy, disease resistant grass be obtained.

The system has proved successful in Germany. It has made great strides on the British Isles, and in many of Great Britian's territorial possessions. Within the last four years the system has made its appearance in America, and is being put to test at some six different experimental stations. It has proved to be particularly adapted to conditions in New Zealand, and has met with success in sections of Australia.

Details of the Hohenheim System of Pasture Management

The pasture problem at first sight was purely a problem of production. Concentrated feeds were scarce and grass had to take its place in the production of milk. Upon complete fertilization of the land, Dr. Warmbold obtained a very rapid growth of grass rich in protein and very highly relished by the cattle. This rapidly growing grass soon became rank and he realized that this growth must be controlled, so that the stock should always eat the young leafy grass that is characteristic of a highly productive pasture in the spring flush of growth. To accomplish this, he divided the pasture into small paddocks and stocked one of these heavily with milch cows so that it would be eaten down in a short time. When this paddock was eaten off, the milch cows were removed to a second one and so on throughout a series of small paddocks. Immediately following the removal of the high producing cows, a group of dry cows and young stock were placed on the paddock to clean

it up, and they in turn followed the high producers throughout the series of small paddocks. When the dry cows and young stock were removed from a paddock, it received a top dressing of nitrogen to stimulate new growth. By the time the milch cows were brought back to the first plot, it had time to make a moderate growth of highly nutritious and greatly relished grass.

The fundamental principles of the Hohenheim System of Pasture Management are as follows:

1. Division of grassland into paddocks.
2. Division of herd into high producers, low producers and dry stock. (Low producers and dry stock may be combined into one group).
3. Rotation of these groups from paddock to paddock.
4. Complete fertilization with emphasis on the use of large amounts of nitrogen applied in several applications.

The manner in which each of these principles are carried out is described in the following paragraphs.

1. Division of grassland into paddocks. The first step in the construction of a Hohenheim system is the division of the grazing area into small paddocks. The size of the paddocks depends somewhat on the number of cattle to be pastured. The paddocks should not be so large that the herd will not be able to clean it up thoroughly in a period of from ten days to two weeks nor should it be so small that it becomes inconvenient to handle. For a herd averaging about sixty head the paddocks

be about five to six acres in size.

There should be at least five paddocks. With this number of paddocks and two groups of cattle, each paddock will have a rest period of from ten days to two weeks which under average conditions is ample time for a moderate amount of new growth to take place.

A plentiful supply of running water should be provided for each paddock. Tanks may be constructed so as to serve two adjacent paddocks in turn.

2. Division of herd into high producers, low producers and dry stock. A division of the herd is essential for the most efficient use of the pasturage. This division may take one of the several forms, depending on the number of paddocks and the degree of separation the farmer wishes to practice.

One method is a separation into three groups- high producers, low producers,and dry cows and young stock. A more common method, one involving less labor in the handling of the animals, is a separation into two groups, aged cows and young stock. This method has another advantage in that aged cows never come into direct contact with the young stock, and thus any outbreak of readily transmittable disease in the milking herd is not so likely to be commuted to the young stock. Again dry cows in the latter stages of a gestation period need considerable attention and should be brought to the barn each day. If they are placed with the young stock they will receive much less attention and close inspection is difficult.

3. Rotation of groups from paddock to paddock. The moving of the cattle from paddock to paddock requires considerable

thought and keen observation on the part of the herdsman. In this connection the German adage "The eye of the master fattens his cattle" should be fully observed. In the spring when the grass is growing rapidly, the cattle may require two weeks to clean up a paddock. As the dry weather of summer approaches it becomes necessary to move the cattle more often.

Over large areas, such as are required in pasture projects, the type of soil, topography, and drainage may vary, and consequently the pasture flora may differ accordingly, throughout the field. Because of these variations, certain paddocks are usually more productive than others. It is thus impossible to state definitely the length of time a paddock should take care of the herd. The cooperater must survey each paddock carefully and move the cattle rapidly or slowly depending on the actual amount of food present.

4. Complete fertilization with emphasis on the use of large amounts of nitrogen applied in several applications. The subject of fertilization is one requiring careful study and is at present still in the experimental stage. Here again, close observation is essential for there is no one method of fertilization which meets all conditions. There are many variables which must be taken into consideration in determining a fertilization program, such as climate, soil conditions, flora present, types of animals to be used in grazing. However, in general, results indicate that a complete fertilization program is most efficient. The phosphorus and potash applications made at one time may be heavy enough to last for two or three years.

The nitrogen, due to danger of loss by leaching, should be applied every season and under most conditions several times during a season. The use of nitrogen in various amounts, and its application at different intervals during the growing season is under experimentation, and it is hoped that a more definite nitrogen fertilization program will result.

Precautions. There are several precautions in the scheme, which must be carefully observed. First, if the total number of animals is insufficient to keep the grass eaten down closely, then one or more of the paddocks should be cut for hay.

Second, the fouling of the pasture must be prevented, and this can be accomplished by harrowing several times during the season to scatter the droppings.

Third, there is the problem of barn feeding. With a large herd a little feed must be fed in the barn to attract the cows to their respective stalls. Also a little concentrated feed, high in carbonaceous ingredients and very low in proteinaceous material, will aid materially in balancing the ration of the animals. Care must be taken not to feed any highly proteinaceous food stuff for that would still further unbalance an already poorly balanced ration.

Early Principles of Grassland Culture

The principles Dr. Warmbold made use of in his experiment are not new ideas nor discoveries. His successful combination, however, satisfied the grazing farmer whose needs were so justly described by William Curtiss in 1777(2). After describing various grasses he writes, "It appears to us that

in the herbage of a good meadow there must be a combination of Produce, Bateableness and Early Growth. Produce in most cases, is the agriculturists grand object, and no wonder, since it is the quantity chiefly which enables him to pay his rent and support his cattle. Bateableness is used to express the cattle's thriving on the food they eat. It is well known that clovers, lucerne, etc., fatten cattle, but what grasses have this particular tendency remains to be ascertained by experiment. Early growth is needed to supply the wants of the grazier, and therefore grasses that put forth early foliage and are grateful to cattle deserve attention."

The men of the eighteenth century did not have the aid of concentrated fertilizers to assist them in promoting the development of the desired grasses. But they did resort most highly to the means at hand to promote the development of the better grasses, and secure the most efficient use of the forage present, as shown in the following quotation from Marshall, 1788 (3). "In all cases, where fattening cattle or dairy cows make up a part of the stock, and where situations, soil, and water permit, every suite of grazing land ought, in my idea, to consist of three compartments. One for head stock, one for followers, and a third to be shut up to freshen for the leading stock.

"If at the time of shifting the followers there be much seedy herbage left upon the ground, it ought to remain until they be shifted and to be mowed as hay during the recess.

"But, if at that time, a few weed and a little seedy herbage only be left, they ought to be swept down with a

scythe a few days before the removal of the lean stock; which will not fail in this case, to lick up even the sharpest thistles, while they are in the soft, placid state, to which mowing presently reduces them, not a weed ought to seed, nor a tuft of stale grass be suffered to stand in a pasture ground; which ought once, at least, during the summer, to be leveled with a scythe; thus, at a small expense converting weeds into nutriment and waste grass into aftermath."

Marshall and his co-workers advocated rotational grazing, realizing that grass in the young stage, characteristic of spring growth, is highly nutritious. By heavily stocking small paddocks in rotation they could prevent the grass from becoming rank.

They advocated mowing to mitigate the smothering effect upon clovers and the better grasses by the growth of rank grasses and weeds.

They advocated a division of the herd. Realizing that the young fresh grass will be used more efficiently by the heavy producers, thus giving them the first bite off each paddock. The poorer producers and dry stock should follow, because they can be made to clean up the paddock without any loss in production.

By following the methods advocated by Marshall, the grazing farmer was able to obtain Produce, Bateableness and Early Growth to a marked extent.

Dr. Warmbold, in addition to these fundamental factors, recognized another still more potent factor,-that of using large quantities of nitrogen fertilizer. He also re-

cognized that grasses upon complete fertilization can be made to produce a rank growth and that this growth should be controlled to secure the most efficient use of the grass.

It is said that in 1914(4) Dr. Warmbold visited a farm on the Island of Jersey, where a very intensive system of pasture management had been in vogue for some twelve years. "He was interested in the small fields, grazed off in rotation, eaten down by followers-on, fertilized with nitrogen and shut up for the next crop of grass to be eaten off in the leaf stage."

It is evident that Dr. Warmbold's scheme is very similar to that practiced on the Jersey Island farm, which in turn includes many of the principles advocated by Marshall long before. However, Dr. Warmbold made a very intensive study of the fertilization of grassland, and to him should be given the credit for the scientific use of fertilizers in grassland culture.

The Study of Pasture Grasses

It is of interest to study the development of our knowledge of pasture grasses. At present with great strides being made in the study of the pasture flora, we are beginning to realize that we have not been fully aware of the economic value of our pasture herbage.

The early workers were interested in the botanical side of the problem of pasture improvement. With the appearance of concentrated fertilizers the chemist has become involved, and today is taking the leading part. With fertilizer he can stimulate the growth of certain species and by chemical analysis of the flora he can determine the types of

plants he will want to stimulate.

Interest in the pasture flora is comparatively recent. A few workers of the early nineteenth century studied the pasture flora in an attempt to determine botanical and chemical variations, however, their findings never became of much significance. Writing so recently as 1924, Professor T. B. Wood(10) stated that no exact figures were available for the composition and feeding value of grass as grazed by animals.

Probably the first studies on the chemical composition of grasses were made by the German chemist Müller as early as 1873 (5). From his findings he suggested that the nutritive value of pasture grasses as well as their fertilizer needs, could be determined from their chemical compositions.

About this time the sowing of grass seeds other than rye grass was greatly on the increase in England. In 1882 Mr. Faunce De Laune (9) contributed a report to the Journal of the Royal Agricultural Society which induced many to try a mixture of natural grasses.

In 1883 Mr. George Sinclair (9) carried on a complete set of experiments attempting to determine the comparative values of different grasses under environmental conditions which were thought best suited to the individual plants. He also determined the nourishing properties, as best he could, of the various grasses and published the results in his Hortu Woburnensis, which was the standard book on grasses well into the beginning of the twentieth century.

However, with the advance in methods of chemical analysis, Sinclair's determinations on the nutritive value of

grasses were found to be unsatisfactory. Mr. T. T. Way, 1884, after perfecting more accurate methods of determining the nutritive value of grass, published the analysis of British grown specimens of the commoner permanent grasses. This was probably the only complete analysis of grasses up to that date.

After the published works of Way a large amount of work was started on this subject both in Germany and America. Way examined all of his plants at the time of flowering. The results of the German and American investigations showed that there is a greater difference between the composition of the same grass cut at different stages of its development than between different varieties cut at the same stage of development.

It seemed worthy to supplement the work of Way and Sinclair, especially in view of the greatly increased interest in the subject of grass seeds that had followed the publication of Mr. De Taune's paper. In 1884 Mr. Wilson set up a very complete experiment to determine the value of many of the different grasses grown in the British Isles.

Mr. Carruthers, writing in 1891 (1), says, "I venture to re-arrange in the following table some of the data contained in Mr. Wilson's paper with the view of bringing out more clearly these conclusions.

"The chemical composition of equal weights of different kinds of grasses, grown under equally favorable conditions and examined at the same stage of their life history, show unimportant differences. However, the feeding value of the same grass differs very greatly at different stages of

its life. When it is in the leaf stage, every cell is charged with protoplasm, and the whole plant is busy making food, first for the building up of its growing tissues, and then for storing up for future use whatever is not required for growth. The throwing up of the flowering stem consumes some of this stored food, converting much of the soluble carbohydrates into insoluble fiber, the development of flowers uses still more, and the remainder is transferred to the seed as it gradually ripens. These operations modify greatly the quality and quantity of the food at the various stages of the plants life."

The data of Mr. Wilson, rearranged by William Carruthers to show the comparative food value of grasses at different stages of their life, is given in the following table.

Comparative Food Value of Grasses at Different Stages of Their Life

	In full bloom	Beginning to bloom	After bloom	Seeds ripe
Cocksfoot	137	100	87	70
Foxtail	148	106	89	81
Tall Fexcue	136	103	92	73
Meadow Fescue	149	116	82	74
Sweet Vernal	146	113	89	82
Golden Oat Grass	140	97	80	77
Timothy	137	104	83	89
Rye Grass	136	106	84	78
Wood Meadow Grass	129	101	91	80
Rough Stalked Meadow Grass	112	104	100	73
Crested Dogstail	131	106	83	74
Hard Fescue	145	99	108	100

This table, in its perpendicular columns, shows the nearly equal feeding value of the different grasses when analyzed at the same stage of their life history; and in its horizontal lines it shows the gradual decrease in the feeding value of each kind of grass as it grows older.

The paper of De Laune's (9) and the work of Sinclair, Way and Wilson (9) was largely concerned in increasing the nutritive value of pastures by the proper selection of various greaases and legumes. However, the first serious attempt to secure definite information in regard to the nutritive value of pasturage and its improvement by manurial treatment was performed by Somerville and his coworkers in 1898 (9). Their celebrated series of investigations popularly known as the "Manuring for Mutton Experiments" is common knowledge throughout England. The British practices of grassland management, up until the last few years, was founded upon the results of Somerville's investigations. The practice is chiefly to develop white clover in pastures, which follows the application of basic slag or other phosphate manures.

In 1907 Armstrong (10) made some valuable investigations in respect of the botanical and chemical composition of the herbage of pastures. He concluded that in the bulk of the better pastures the herbage consisted of white clover and rye grass.

He also showed that herbage of the best pastures may be twice as high in nitrogen and phosphorus as the herbage of inferior pastures. He maintained that this difference was due to the larger proportion of white clover present, and indirectly to the percentage of available phosphate in the soil.

The next contribution of importance on the subject was the classical investigation carried out by Hall and Russell (10). They demonstrated that the feeding value of

pastures was controlled by two main independent factors; floral type and habit of growth. The botanical composition of the herbage was affected by climate, reaction of the soil and the treatment of the grass, but was not necessarily influenced by variations in the amount of nitrogenous plant food present. The factors governing the habit of growth appeared to be the supply of phosphate and the rate of ammonification and nitrification in the soil. Cases were described where the general soil conditions and floral type were very similar in two adjoining fields, but the habit of growth and feeding value of the grass were markedly different. In such cases it was noticed that a leafy habit of growth characterized the fattening fields and a stemmy habit the poorer fields.

An investigation into the composition and digestibility of some of the important meadow grasses was made by Honcamp and his co-workers in Germany between the years 1910 and 1915 (10). Their results appear to justify the conclusion that good grasses grown under similar conditions possessed approximately equal feeding values.

In the present decade the interest in pasture problems has received new interest. Investigations are being carried on in all pastoral countries. The leaders in this new revival of pasture research probably center around such investigators as Stapledon and his collegues at the Welsh Plant Breeding Station, and of no less importance is the work being done at the Rowett Research Institute on the question of the mineral content of pasture herbage.

The problem of grassland culture naturally centers about the plant and as such it differs from one country to another, because of variations in species, and may also differ within a definite locality because of variations in soil conditions, etc. Because of these many variations which occur, investigators are working in different countries with problems which are seemingly of local interests, and as a result discoveries of value are kept within the locality. Not until recently has any attempt been made to bring together available literature and findings on the subject of grassland culture, and an attempted correlation been made between problems of different localities and the causal factors.

In this attempted correlation it has been found that many problems in far different localities have at their root a common cause. This compilation of available information is taking place at the Rowett Research Institute (7), and it has already brought to light many facts of practical importance.

Probably the most important feature brought out by this work to date is the fact that many diseases among cattle and sheep in various countries are due to a lack of phosphorus in the herbage. This information is of great value to the grazing farmer, for if the phosphorus deficient localities are once isolated, it will enable farmers in these sections to take measures to prevent the onset of diseases due to this deficiency.

It is hoped that with the co-operation of

scientists throughout the world working on the problems of grassland culture that soon more efficient use will be made of the grazing land which is becoming less productive as the years pass by.

Summary

Any system of agriculture, however primitive, finds a place for the grazing of livestock. Grass is the only natural food which contains all the essential elements in the proper proportions to maintain normal healthy growth among herbivores. Methods of grassland culture with centuries of tradition behind them, had developed to such a degree of refinement along certain lines that, until the end of the last century, the scientist could hope to do nothing more than provide explanations in terms of modern scientific knowledge for the empirical methods based on age-long experience. However, with the development of artificial fertilizers, the scientist has been able to make some real contributions to grassland culture. His work has made it possible to encourage early growth in the spring, late growth in the fall, encourage better varieties of grasses, and discourage less useful varieties, and weeds. All this has led to greater production, which in the end, is the agriculturists grand object.

One of the biggest forward steps in this direction was the introduction of the use of basic slag in improving pastures. Its use became particularly prominent in the British Isles and has remained so to this day. With the arrival of the "era of nitrogen plenty", it is possible to

make unbelieveable strides towards greater production from grassland. The Hohenheim System of pasture management, the essential feature of which is complete fertilization with particular emphasis on the use of nitrogen in several applications, had its origin in the work of Dr. Warmbold at Hohenheim, Germany. The system is being adopted in Germany, France, England, and many other pastoral areas in the world. It is probable that the system will raise the output of grassland to a point comparable with that of arable husbandry. The chemistry of grass and its nutritive value have also become subjects of outstanding interest, and it is hoped that knowledge on this subject will soon be made more available to the great pastoral areas of the world.

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