Appendix A

Detailed statistics of dracunculiasis patients collected in some of the guinea-worm infected villages

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of the village</th>
<th>Population</th>
<th>No. of houses</th>
<th>No. of infected houses</th>
<th>No. of persons living in these infected houses</th>
<th>No. of persons who suffer from the disease every year</th>
<th>No. of persons who suffered from the disease only last year</th>
<th>Infection of the step-wells with cyclops</th>
<th>AGE</th>
<th>SITUATION OF THE WORMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Medikoppura</td>
<td>800</td>
<td>124</td>
<td>41</td>
<td>287</td>
<td>47</td>
<td>14</td>
<td>+++</td>
<td>M</td>
<td>F</td>
</tr>
<tr>
<td>2</td>
<td>Chikkondahally</td>
<td>650</td>
<td>110</td>
<td>30</td>
<td>240</td>
<td>51</td>
<td>8</td>
<td>+++</td>
<td>F</td>
<td>M</td>
</tr>
<tr>
<td>3</td>
<td>Yarabollly</td>
<td>985</td>
<td>200</td>
<td>36</td>
<td>204</td>
<td>56</td>
<td>4</td>
<td>++</td>
<td>M</td>
<td>F</td>
</tr>
<tr>
<td>4</td>
<td>Gollorhatti</td>
<td>500</td>
<td>80</td>
<td>34</td>
<td>138</td>
<td>52</td>
<td>7</td>
<td>++</td>
<td>M</td>
<td>F</td>
</tr>
<tr>
<td>5</td>
<td>Bommakanallly</td>
<td>150</td>
<td>30</td>
<td>8</td>
<td>56</td>
<td>15</td>
<td>2</td>
<td>++</td>
<td>M</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>3,085</strong></td>
<td><strong>544</strong></td>
<td><strong>149</strong></td>
<td><strong>925</strong></td>
<td><strong>221</strong></td>
<td><strong>35</strong></td>
<td><strong>...</strong></td>
<td><strong>M</strong></td>
<td><strong>F</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2-5 years</th>
<th>5-15 years</th>
<th>15-30 years</th>
<th>30-50 years</th>
<th>Above 50 years</th>
<th>Lower extremity</th>
<th>Uprone</th>
<th>Abdominal and chest</th>
<th>Other rare situations</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>F</td>
<td>M</td>
<td>F</td>
<td>M</td>
<td>F</td>
<td>M</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>7</td>
<td>5</td>
<td>22</td>
<td>10</td>
<td>9</td>
<td>2</td>
<td>5</td>
<td>...</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>13</td>
<td>12</td>
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<td>1</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>10</td>
<td>8</td>
<td>10</td>
<td>8</td>
<td>13</td>
<td>5</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
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<td>1</td>
<td>3</td>
<td>33</td>
<td>26</td>
<td>61</td>
<td>48</td>
<td>17</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>326</td>
<td>4</td>
<td>217</td>
<td>31</td>
<td>7</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A Biological Method for the Control of Dracunculiasis*

By V. N. Moorthy, B.Sc., M.B., B.S., D.P.H., D.T.M.
and
W. C. Sweet, M.D., Dr. P.H.

In two earlier articles (Moorthy, 1932 and 1932a) reference was made to the probable usefulness of certain species of fish in the control of dracunculiasis, due to their habit of feeding on cyclops and guinea-worm embryos. This biological method has been in use in the Chitaldrug district of the Mysore State since 1931 and this report covers observations on its utility as a practical field measure for the control of guinea-worm disease.

A survey of the Chitaldrug district made in 1929 showed that

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*The work here reported was begun by the Mysore State Department of Health and continued with the support and under the auspices of the Department of Health, Government of Mysore, and the International Health Division of the Rockefeller Foundation.

about 250 out of 1,400 villages depended entirely on step-wells for their water supply and that 112 of these villages had dracontiasis to a greater or lesser degree. In 1935 only 25 villages showed cases of this disease. Some of this decrease was undoubtedly due to other causes but the methods adopted for control were the following:

1. Certain of the step-wells were converted into draw-wells by enclosing them with a parapet wall after providing a platform from which water could be drawn.
2. Provision in villages of new draw-wells.
3. Fortnightly treatment of step-wells with lime, perchloror or copper sulphate during the transmission season, from December to May.

The first two measures mentioned are permanent and result in complete control of guinea-worm disease when they are effectively introduced. No other control methods should be considered as anything but temporary substitutes for these permanent measures. However, the conversion of step-wells and the provision of draw-wells are expensive and sometimes ineffective due to village prejudice and to the quality of water supplied by the new well.

The chemical treatment of step-wells is temporary in its effects (Moorthy, 1932a), and expensive in chemicals and staff, while the use of certain species of fish has been found to be effective, cheap, more permanent, and frequently popular with villagers.

**Early field and laboratory observations**

During early field studies in the Chitaldrug district certain observations were made which led directly to the trial of fish as a control method. The village of Kelgote, discussed later, gave a demonstration of the usefulness of fish, as did four other villages in which dracontiasis had disappeared following floods which had stocked the step-wells with small species of fish. In another village the drying up of one step-well with the consequent use for eight years of another well, naturally stocked with fish, led to the disappearance of guinea-worm disease until the original step-well was again put into use. It was also observed that no village in which the step-well contained these small species of fish had dracontiasis and that the density per dip of copepods in these wells was much lower than in wells with no such fish.

![Step-well A2, Medikerepura.](image)

Step-well A, Kelgote.

From specimens of fish collected in step-wells of the Chitaldrug district, Dr. S. L. Hora of the Indian Museum identified 16 different species (Hora, 1936). The following six species were found to be of use in guinea-worm control:

1. *Barbus (Puntius) pucelli.*
2. *Barbus (Puntius) ticto.*
5. *Barbus sophore.*

To these fish have since been added a species of Gambusia, imported from Italy, which has also been found useful. All of these species of fish feed on such copepods as cyclops, daphnia, cypris, and diaptomus, both under laboratory and field conditions, although *B. pucelli* and *B. ticto* are the most active in this respect. The *Barbus* species, *L. thermalis,* and Gambusia also feed on guinea-worm embryos under laboratory conditions although these embryos emerge weakened but alive in the faces of all except *pucelli.* *L. thermalis* is a bottom feeder and commonly lies buried in the mud so that its intestinal contents contain many early forms of copepods and various types of ova; it is possibly most useful in destroying the ova and early forms of cyclops. Gambusia used alone for control allows wide variations in the density of copepods, depending on the presence or absence of young fish, but is especially effective as a species in lowering the density of diaptomus. The use of all these species of fish together makes an ideal combination and with their presence in a step-well the density of all copepods, including cyclops, remains very low.

Any species of fish to be useful in dracontiasis control should feed on and digest copepods, especially cyclops, should be a prolific breeder, and should have its breeding season just before or coincident with the guinea-worm transmission season. The use of one species of bottom feeder is apparently an advantage. No reliable information is available as to the distribution in India of the species of fish already mentioned but it is quite possible that other species in other parts of India would fulfil these requirements.

The method of counting cyclops and other copepods in water should be described. Collections are made with a linen tow net ending in a glass tube. The net has a rod six feet in length and the same net is used for all counts. From 100 to 150 dips are taken in various parts of the well and the copepods collected in the glass tube are separated visually by pipettes into three clean bottles labelled 'cyclops', 'diaptomus', 'others'. The copepods are then killed with formalin and later counted under a microscope in the laboratory. The average number per dip can then be calculated.
Kelgote village (map 1)

Kelgote, with a population of 608, can be divided into three groups according to the source of water used. One end of the village, 86 people, used water from step-well A, which contained most of the species of small fish mentioned before; these had been naturally introduced and there were histories of only sporadic cases of guinea-worm infection amongst this group. The second division, 361 people, used water from step-well B, containing no fish, and histories indicated an average annual occurrence of 46 dracuated cases, while the 161 adikarnatatas had no history of infection and used water from draw-well C.

After thorough treatment with copper sulphate and perchloron, specimens of each species of fish present in well A were transferred to well B on 30th May, 1931, and careful counts of copepods from B and from a comparison step-well D were kept in following years. Step-well D contained no fish and the water was not used for drinking. The fish in well B multiplied rapidly and since early 1932 the number of cyclops per dip has never exceeded 10: the water of well D has continued to yield from 680 to 1,200 cyclops per dip.

Among the people using water from step-well B there were 22 cases of dracuated in 1932, 4 cases in 1933 and no cases since (up to June 1936). This occurred in spite of the presence in a hut (E, map 1), near the step-well, in 1935 of two guinea-worm cases from Bellary who were seen actually infecting the water with embryos during the transmission season.

Medikerepura village (map 2)

Medikerepura village has a population of 1,003 persons, made up of 719 caste people. 46 adikarnatatas, and 238 luumbanys. The majority of the caste people use water from step-well A₁, since the water of their draw-well is brackish, and their history indicated an annual average of 113 cases of dracuation. The adikarnatatas, use water from a shallow step-well in the fields, B₁, and gave a history of about 22 cases per year, while the luumbanys use water from a draw-well, C₁, within 30 yards of B₁, and are completely free from this infection. Another step-well, D₁, was used for comparative purposes.

The step-well A₁ was thoroughly treated with perchloron on 3rd February, 1934, and was stocked with 100 specimens each of B. puckelli, B. ticto, B. chola, B. sophore and L. thermalis on the 26th February. Step-wells B₁, and D₁ received no chemical treatment nor were fish introduced. The initial cyclops count of well A₁ was 500 per dip, a count which was reduced to zero four days after the perchloron treatment and had been restored to 28 per dip on the day the fish were introduced. Large numbers of young fish were first seen on 18th June, 1934, when cyclops count was 87 per dip. On 25th March, 1935, the count was 10 cyclops in 50 dips and since then there has been some variation but no count has been above 18 per dip. Counts in B₁, the adikarnataka well, have never been below 240 cyclops per dip and in C₁, never below 428.

Against the average of 113 cases of dracuation among the 719 caste people there were eight cases in 1935 and no cases at all in 1936. Amongst the 86 adikarnatatas, whose step-well was not treated in any way, there were 14 cases in 1935 and 18 cases in early 1936, as compared with the annual average of 22 cases previous to 1934. The adikarnataka step-well was stocked with fish in June 1936.

The very marked reduction of infection in this village one year after the introduction of fish and its complete disappearance thereafter were probably due to the fact that the fish were introduced early in the guinea-worm transmission period and just at the breeding season of B. puckelli. Neither of the conditions was true in Kelgote village where the initial reduction was not so marked and cases occurred in the second year.

Routine control measures

Since 1934 fish have been introduced into step-wells in 35 infected villages with the result, where careful records have been kept, that guinea-worm disease has disappeared in six and been markedly reduced in four. In certain of these villages the fish have not survived and this difficulty will undoubtedly be met with occasionally in other areas where this method is tried. Investigation has shown that this may be due to the bailing out of water to remove silt, to the drying up of the well in summer, to unexpected treatment with perchloron or overdoses of potassium permanganate, or to the catching of the fish for eating when the water is low. It is also probably true that certain waters on account of their chemical or biological peculiarities will not support these fish.

The first measure in routine control of guinea-worm disease by fish is the establishment of hatcheries from which the various species will be always available. In the Chitaldrug district this has been done in 73 taluk and hobli headquarters. It should also be noted that each successfully-controlled step-well can become a hatchery for the supply of fish to neighbouring villages.

Any step-well to be stocked with fish should be previously treated with perchloron (3 lbs. to 100,000 gallons) until it is free of cyclops. Should this measure result in odour due to decaying organic matter, a small dose of potassium permanganate will remedy matters. The perchloron, if used properly, will kill many of the predacious species of fish and leave the well free for the smaller species used in control. It is best to encourage the villagers to bail out the wells and remove silt before the treatment with perchloron is used.
About 100 specimens of each species of fish used for control should be freed in the well about one month after the dosing with perchloron. The fish may be transported in large cans with mesh tops either by lorry or cart, avoiding shaking as much as is possible.

A small staff of one or more sanitary inspectors, depending on the size of the area to be covered, and the necessary peons should supervise the stocking of wells, check up the breeding and presence of the fish in the wells, and record results of the work. It should be noted that this method can be used not only in infected villages but also in other areas in which the disease occurs sporadically, due to the use of step-wells for a drinking water supply to which wandering cases of dracunculiasis have access.

The custom of keeping fish in the drinking water supply is apparently widespread in India so that the fish control measures fit in with an existing habit. From our experience it is not difficult to teach the villager the proper species to use and he rapidly becomes an enthusiastic and vigilant co-operator in the control of his own step-well. In this connection, it is of some interest to note that, unlike Gambusia, the Barbus species used in control of cyclops will cluster around the submerged portions of the body of people using the step-well and pull at hairs and loose epidermis enthusiastically. This habit has been noted by the village people and it is made use of in some areas as a treatment for certain types of skin diseases and ulcers.

The fish control of dracunculiasis is more permanent, more efficient and much cheaper than the usually chemical methods of control but it should be again emphasized that the abolition of step-wells is the only permanent and fool-proof measure for the control of this disease.

Summary

The control of dracunculiasis by the use of certain small species of fish which ingest cyclops and other copepods is suggested, and the freeing of guinea-worm infection of two villages in the Chitaldrug district of Mysore State is described. Routine methods in use for fish control are mentioned and it is claimed that these methods are more permanent, more efficient and cheaper than the usual chemical methods of control. It must, however, be emphasized that the abolition of step-wells is the only permanent, fool-proof, method of control.

References


The first paper by V. N. Moorthy reports on the many epidemiological and experimental findings which have laid the ground for a better understanding of the factors that may influence the transmission of Dracunculus medinensis to man. Some of these include biological and behavioural factors, as well as factors genetically related to the species of the intermediate host and perhaps to specific groups of population and the environment. This pioneer paper was published in 1932 in India, the country then the most affected by dracunculiasis. It outlines eradication measures in the absence of drugs to cure the disease and, at the same time, presents a vivid and detailed description of the different clinical manifestations of the disease. Seventy years later, the observations made by Dr Moorthy remain valid and still there are no drugs available. The big difference is that Pakistan and India have both been certified by the World Health Organization as being free of dracunculus transmission—in 1997 and 2000, respectively—after exemplary eradication campaigns. A remarkable achievement indeed!

The second article, by Moorthy and Sweet, published in 1936, reviews several methods for the control of dracunculiasis. Although they placed emphasis on the use of fish feeding on the intermediate host, the paper clearly states the primary importance of the provision of safe water as a key to interrupting successfully the transmission of dracunculiasis. The conversion of step-wells into draw-wells, or provision of new draw-wells are indeed the most appropriate strategies, followed by the combination of chemical treatment of step-wells and the subsequent introduction of appropriate species of fish.

The disease is now confined to only 13 countries, all in Africa. A total of 60 000 cases were reported worldwide in 2001. The key to providing the final push to eradicate dracunculiasis remains first the provision of safe water to the last and more remote communities still affected by the diseases, in combination with the case containment strategy, which encompasses active case search for early detection and containment of guinea worm cases, health education and the provision of filter cloths.

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