# Information from Radio Telemetry on movements and exploitation of naturalized Rainbow trout, *Oncorhynchus mykiss* (Walbaum), in Kenya cold water streams

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## ABSTRACT

Rainbow trout populations in Kenya streams have declined rapidly over several decades. Therefore, we studied movements of rainbow trout, *Oncorhynchus mykiss* (Walbaum), in two third order streams (the Sagana and Thego) on the southwestern slope of Mount Kenya between February and December 1998. Fish implanted with dummy transmitters and held at the Kiganjo Trout Research Station had surgical wounds healed, on average, within eight days and fed three days after surgery. The proportion of tagged fish moving upstream was higher in all the stations than those moving downstream. Estimated distances traveled by rainbow trout between observations varied from 0 to 1.2 km in the Sagana and from 0 to 1.09 km in the Thego. All recaptured radio-tagged fish in the Thego grew; indicating that they recovered well from surgery, and actively foraged following release. Illegal fishers caught all radio-tagged fish released in the Sagana indicating that the recovery of trout population in this, and probably other trout streams, will require strict enforcement of fishing regulations.

**Key words**: Naturalized, rainbow trout, exploitation, radio-telemetry, and regulations

## INTRODUCTION

Biotelemetry has been used extensively to monitor the activities of aerial, terrestrial and aquatic animals (Adams *et al.*, 1998b). Radio telemetry has been used to study a variety of salmonid fish, including rainbow trout, *Oncorhynchus mykiss* (Mellas and Haynes 1985; Lucas 1989), Atlantic salmon, *Salmo salar* (Moore *et al.*, 1990; Amstrong and Rawlings 1993), and Chinook salmon, *Oncorhynchus tshawytscha*, (Adams *et al.*, 1998a; Adams *et al.*, 1998b). Fish are difficult to observe visually in the wild, but biotelemetry allows fish biologists and managers to gather data on fish activities that otherwise would be unattainable. Information on fish, movement, swimming, distribution, feeding, habitat selection, survival and growth can be collected by use of telemetry.

We studied rainbow trout populations in the Sagana and Thego streams on the southwestern slope of Mount Kenya. Electrofishing done during this study indicated that the distributional range of rainbow trout has contracted since the early 1950s. Several factors may have contributed to the reduction in the distribution of rainbow trout in these streams, among them being over-exploitation of the rainbow trout stock. To aid in collecting information on the exploitation rate of rainbow trout, as well as other aspects of their biology, we tagged rainbow trout with radio tags.

## MATERIALS AND METHODS

### Study area

The two investigated third order streams (the Sagana and Thego) share the same climatic 'zone' but have different levels of upstream human activity on their watersheds (Fig.1). The Sagana has a catchment of about 119 km$^2$ and rises at about 4000 m from the southeastern slope. It drains westward and later turns east to discharge into the Indian Ocean as the Tana River. The Thego, with a catchment of about 114 km$^2$, is a major tributary of the Sagana and also rises from the southeastern slope of Mt. Kenya at about the same altitude. It initially drains west and later joins the Sagana to flow east. Three representative sections (a stream section was about 3 km.) in each stream were selected as study sites. The altitude of the study sections of the streams varied between 1645 to 2285 m, they are referred to as upstream (S1and T1), midstream (S2 and T2) and downstream (S3 and T3) stations.

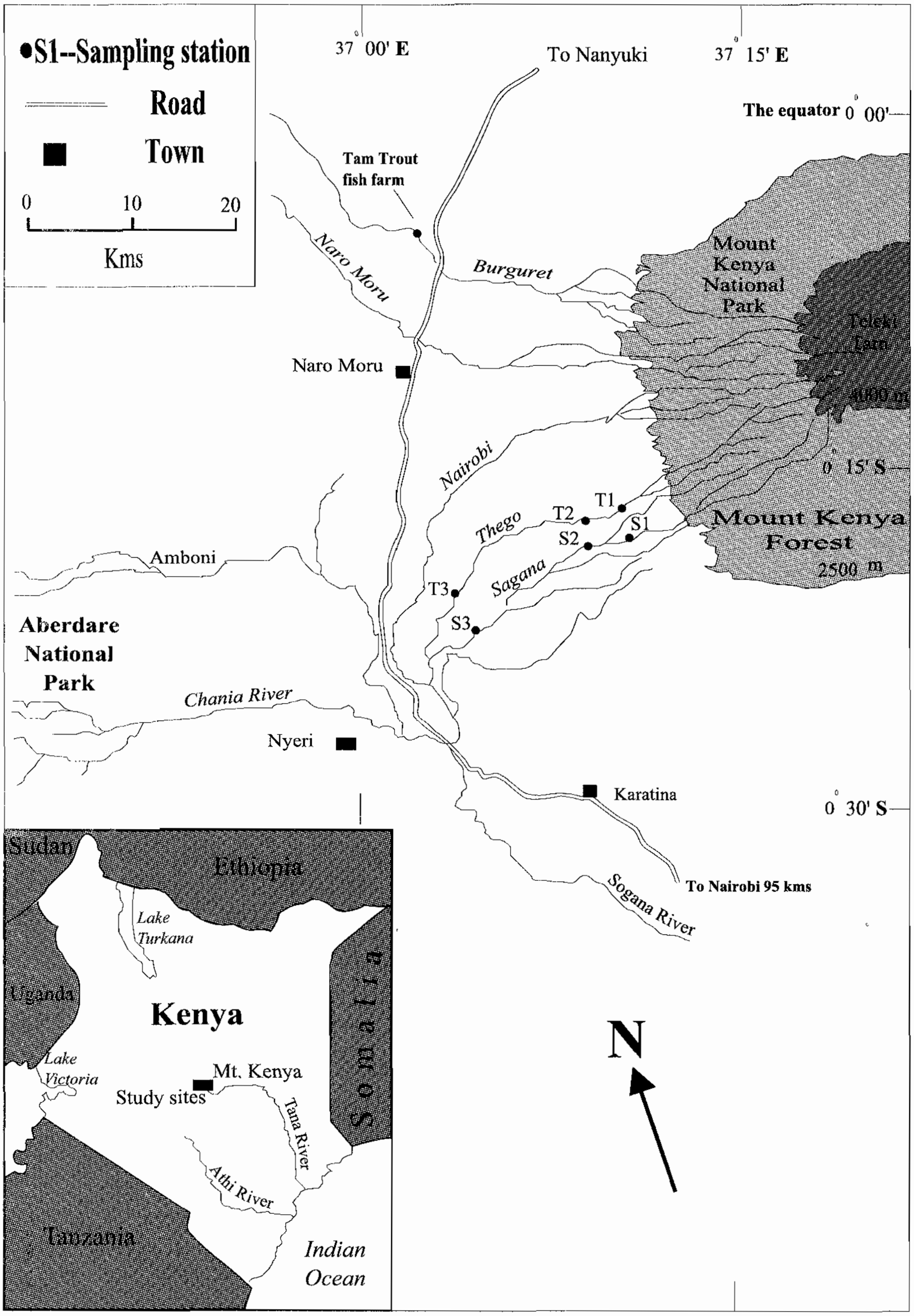


Fig. 1 The location of study sites on the Sagana (S1, S2 and S3) and Thego (T1, T2 and T3) streams. The map also shows the Kiganjo Trout Research Station and the Tam Trout fish farm where fish specimens were obtained for tagging.

Water temperature and stream discharge for the Thego recorded at station T3 varied with months with noon temperature ranging from 12.9 $^0$C to 19.6 $^0$C from 20$^{th}$ August to 6$^{th}$ December 1998. Stream discharge in the Thego at station T3 ranged from 0.094 to 1.28 $m^3s^{-1}$ from 20$^{th}$ August to 7$^{th}$ December. Pools averaged 20.53 m in length with depths of about 2 m while runs were on average shallow but averaged about 30 m in length. The streams had channels of similar width that varied with the altitude and season, generally ranging from about 9.0m upstream (S1) to about 14.5m downstream (T3) during the rainy season. They exhibited a continuous flow with variation in depths and velocity influenced by rainfall pattern.

## METHODS

Radio or dummy transmitters were surgically implanted in 26 rainbow trout between February and December 1998. The radio tags (Lotek model # MCFT-3EM) had a battery life of approximately 180 days. They measured 11 mm in diameter, 49.3 mm in length, and weighed 4.8 g in water. The fish used weighed more than 500 g on average and consequently transmitters were always less than 2.0 % of the body weight as recommended by Winter (1983). Since fish of this size could not be caught in the streams, specimens for tagging were obtained from the Kiganjo Trout Research Station and the Tam Trout fish farm (Fig. 1).

Eight fish were implanted with dummy transmitters (the same size and weight as radio-tags) and placed in a cage in a raceway at the Kiganjo Trout Research Station. They were held in the cage to observe the effect of implanted tags, especially how long it took them to resume feeding and for the wound to heal. Some of these fish suffered injuries as a result of contact with the wire sides and bottom of the cages. Consequently, most radio-tagged fish were released directly into the stream following tagging. Radio tags were implanted in February 1998 for the fish transferred to station S1 and station S2 in the Sagana. Fish transferred into the Thego (T3) were implanted with radio transmitters in May, June, July and August 1998.

Transmitters were surgically implanted using the methods described by Lucas (1989) and McKinley *et al.*, (1992). Fish were anaesthetized with clove oil dissolved in absolute ethanol. After about 3 minutes, the fish lost their equilibrium and were transferred to a surgery board. A near mid-ventral incision about

2.5 cm long was made just anterior to the pelvic girdle. This area has been found to provide enough muscle to make it less likely that sutures will pull out (Mckinley *et al.*, 1992). The radio tag was then gently inserted and pushed anteriorly into the body cavity. The incision was closed with 3-4 sutures of non-absorptive silk. Surgery took an average of 6 minutes.

After surgery, fish were allowed to recover in a plastic cage placed in flowing water. They were given about 5-10 minutes after they regained equilibrium, which took 2-3 minutes while in the plastic cage, before they were placed in a cage or into a container for transfer to a stream. Radio-tagged fish were identified by their characteristic radio frequencies and signal pulse rates. Each was assigned a code number.

The fish released in the Thego were surgically implanted with transmitters at the Thego Fishing Camp and released into the stream immediately after they recovered from the anesthesia. Other fish were implanted with transmitters at the Kiganjo Trout Research Station and transported by vehicle to the upstream sites on the Sagana, a distance of about 20km (S1) and 17 km (S2). The location of each fish was determined regularly using a hand held receiver (Lotek model # SRX-400) with a dipole antenna. When necessary, a yagi antenna was also used. The minimum distance a fish had traveled since its last known position was calculated after each tracking session. We used rod and line to recaptured the radio-tagged fish. Their total length (cm) was measured to provide information on growth performance.

## RESULTS

The surgical wounds of fish implanted with dummy transmitters and held at the Kiganjo Trout Research Station healed, on average, within eight days and the fish began feeding three days after surgery. The movements of radio-tagged rainbow trout are summarized for the Sagana stations S1 and S2 and for the

Distances are in metres measured from the point of release and P indicates the removal of the fish from the stream by poaching. Total is the sum of the distances traveled in all directions.

Table I Distances moved by radio-tagged rainbow trout monitored in the Sagana (stations S1 and S2)

| | Radio Transmitter Tag Codes for Fish Tracked in the Sagana | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | 925-4 | 895 | 025 | 856 | 925-5 | 845 | 855 |
| 23/2/98 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24/2/98 | +150 | +750 | +200 | +50 | - 50 | 0 | +20 |
| 25/2/98 | 0 | 0 | 0 | 0 | P | P | P |
| 27/2/98 | 0 | +100 | +50 | 0 | | | |
| 11/3/98 | +200 | +350 | +250 | +30 | | | |
| 14/3/98 | P | P | +400 | P | | | |
| 27/7/98 | | | P | | | | |
| Total | +350 | +1200 | +900 | +20 | +50 | 0 | +20 |

Distances are in metres estimated from the point of release. Positive numbers indicate upstream movement and negative numbers indicate downstream move ment. R indicates recaptured fish and * indicates a fish that moved upstream out of range. Total is the sum of the distance traveled in all directions. Four of the eleven radio-tagged fish were not tracked but were recaptured and their specific growth recorded.

Thego station T3 in Tables I and II respectively. The majority of fish moved upstream at all the stations but estimated distances between observations varied from 0 to 1.2 km in the Sagana and from 0 to 1.09 km in the Thego. Radio-tagged rainbow trout in both streams showed a tendency to move upstream; however there were a few fish that either remained in the same pool where they were released or moved downstream. Fish that were released in the Thego spread from their point of release but stayed within about 1 km. However, fish with code numbers S1, F0 and F7 in this stream moved upstream soon after the water level rose. As evidenced by daily tracking, fish that moved upstream spread out into pools with each fish occupying one pool. Radio-tagged fish in the Sagana were monitored for a much shorter time than in the Thego. We recaptured ten of the eleven radio-tagged fish in the Thego from separate pools compared to none in the Sagana; this was over 90% recovery.

Table II Distances moved by radio-tagged rainbow trout monitored in the Thego (stationT3)

| Radio Transmitter Tag Codes for Fish Tracked in the Thego | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | 015 | S1 | S4 | F0 | F7 | F8 | F9 |
| 24/8/98 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25/8/98 | 0 | +30 | 0 | 0 | -50 | 0 | 0 |
| 26/8/98 | 0 | 0 | +30 | +50 | +50 | 0 | +30 |
| 27/8/98 | 0 | +520 | 0 | 0 | 0 | +30 | +70 |
| 28/8/98 | 0 | 0 | +70 | +695 | +695 | 0 | 0 |
| 29/8/98 | 0 | 0 | -70 | 0 | 0 | 0 | 0 |
| 30/8/98 | 0 | 0 | 0 | +100 | 100 | 0 | 0 |
| 31/8/98 | 0 | 0 | 0 | +50 | +50 | 0 | -70 |
| 1/9/98 | 0 | 0 | 0 | 0 | +50 | 0 | 0 |
| 3/9/98 | 0 | 0 | 0 | 0 | 0 | -30 | 0 |
| 4/9/98 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/9/98 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8/9/98 | 0 | 0 | 0 | +50 | R | 0 | +70 |
| 9/9/98 | 0 | 0 | 0 | * | | 0 | 0 |
| 12/9/98 | 0 | 0 | 0 | * | | 0 | -70 |
| 21/9/98 | 0 | +55 | 0 | * | | +280 | 0 |
| 25/9/98 | 0 | 0 | 0 | * | | 0 | 0 |
| 27/9/98 | 0 | 0 | 0 | * | | 0 | 0 |
| 28/9/98 | 0 | +100 | 0 | * | | 0 | 0 |
| 1/10/98 | 0 | 0 | 0 | * | | 0 | +780 |
| 5/10/98 | 0 | 0 | 0 | * | | 0 | 0 |
| 6/10/98 | R | R | 0 | * | | 0 | R |
| 9/10/98 | | | R | * | | 0 | |
| 18/12/98 | | | | * | | R | |

Mean growth rate (fork length increment per day) was 0.035± 0.018 cm with a range of 0.011 to 0.063 cm (Table III). Fish monitored for longer period did not show variation in growth when compared with those that were monitored for relatively shorter period. During the day most of the fish tracked preferred deeper parts of the pools. In the evening most fish were found at the tail end of the pools presumably feeding.

Table III Specific growth of radio-tagged rainbow trout released into the Thego at station T3 (Thego Fish Camp). * Indicates fish whose movements were tracked daily

| Code | Sex | Initial FL (cm) | Final FL (cm) | Period (days) | Growth (cm) | Growth (cm/day) |
|---|---|---|---|---|---|---|
| 000 | F | 32.5 | 37.0 | 152 | 4.5 | 0.030 |
| 001 | F | 34.0 | 38.5 | 218 | 4.5 | 0.021 |
| 056 | M | 35.0 | 39.8 | 193 | 4.8 | 0.025 |
| S1 * | M | 34.5 | 35.5 | 46 | 1.0 | 0.022 |
| S4 * | F | 36.2 | 37.5 | 49 | 1.3 | 0.027 |
| F7 * | M | 36.0 | 36.2 | 18 | 0.2 | 0.011 |
| F8 * | F | 36.5 | 44.0 | 120 | 7.5 | 0.063 |
| F9 * | F | 35.2 | 37.0 | 46 | 1.8 | 0.039 |
| 015 * | M | 28.5 | 32.8 | 69 | 4.3 | 0.062 |
| 895 | M | 28.0 | 32.0 | 76 | 4.0 | 0.053 |

| mean growth rate | 0.035±0.018 |
|---|---|

## DISCUSSION

It has been generally assumed that placement of a transmitter in or on the animal does not cause significant behavioural or physiological change (Lucas 1989; Moore *et al.*, 1990; Knight and Lasee 1996). However, there is little quantitative data available to support the premise that radio-tagged fish behave normally. Mellas and Haynes (1985) compared the effects of externally attached, surgically implanted and gastrically implanted transmitters on swimming performance and behaviour of adult rainbow trout, *Oncorhynchus mykiss* and white perch, *Morone americana* and concluded that gastric implant had the least effect on the study animal. A study by Lucas (1989) however, found that surgically implanted transmitters did not affect mortality or growth and may be preferred for use with adult rainbow trout. Similarly, Moore *et al.*, (1990) reported that surgical implantation of radio transmitters in Atlantic salmon, *Salmo salar*, did not adversely affect growth, feeding behaviour, or swimming behaviour of fish between 127 and 172 mm in fork length.

Results from the work of Adams *et al.*, (1998b) showed that juvenile Chinook salmon between 114 and 159 mm fork length survived and grew with either a gastrically or surgically implanted transmitter. But they further reported that the fish ability to consume food and to grow was affected less by surgically implanted transmitters than by gastric implants.

In this study, cage held rainbow trout with implants began feeding three days after surgery, suggesting that released fish may have commenced feeding as quickly. Growth data from the radio-tagged fish in the Thego showed that these fish grew, indicating that they recovered well from surgery, and actively foraged following the implantation of the radio tags. This is in agreement with the work reported by Lucas (1989), Moore *et al.*, (1990) and Adams *et al.*, (1998b) which identified that surgical procedure alone did not affect growth.

Natural predation did not occur with the radio-tagged fish in both the Sagana and Thego. There was evidence however that a population of otters was residence in the Thego as evidenced by their faecal matter littered on the banks of the stream. From their waste they presumably fed on crabs and other aquatic organisms but not fish.

Illegal fishers caught all the fish released in the Sagana within a period ranging from 2 days to less than a month as evidenced by recovery of tags (from February 25$^{th}$ to March 14$^{th}$). That all the radio-tagged fish released in the upper part of the Sagana were recovered from illegal anglers indicates high exploitation rates. Also, barriers may have reduced movement of radio-tagged fish and hence fish fell prey to the illegal anglers. The Thego fish were not poached and so they were tracked for a longer period ranging from three weeks to three months. Poaching of radio-tagged fish did not occur in the lower Thego, probably because of close monitoring of fishing activity during this period by staff at the Thego Fishing Camp. The high percentage recovery of radio-tagged fish by us through angling suggest that hatchery released fish are highly susceptible to be captured.

Whereas in the 1950s three and four year old fish contributed significantly to anglers' catches, very few older fish now occurred in the study streams. A comparison of data in Van Someren's (1952) report with ours indicates that there has been a marked decrease in average age and contraction of the age distribution and mean size of rainbow trout in the study streams since the 1950s. Age distribution has an influence on the number of fish recruited per season.

In recognition of the current status of rainbow trout and the potential importance of the resource to the country, a comprehensive study and a new management strategy are required to help the recovery of rainbow trout populations.

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