OPTIMUM CONDITIONS FOR TURTLE CULTURE USING LOW TEMPERATURE GEOTHERMAL WATER

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Abstract

Because of its popularity as a food source, there is a great demand for cultured turtles in China. Our tests have shown that optimum production can be achieved by using geothermal water in ponds maintaining a controlled temperature of 25°-30°C throughout the whole year. Other parameters that determine weight gain and optimum hatching are also discussed, together with an economic analysis of turtle farming.

1. Introduction

Culturing of turtles is a growing business in China because mature turtles with a body weight of 0.5 kg or more fetch high prices on the market. Turtles are cold-blooded animals which, under natural conditions, may take up to 5 years before reaching a weight which makes them an economic commodity.

Our studies have shown that turtle growth ceases when water temperature in open ponds drops below 15°C; turtles then enter a dormant state (i.e. during our winter months). However, if turtles are raised in tepid pools with a constant temperature of 25" to 30°C they will continue to grow throughout the year. Similar observations apply to the culture of eels, catfish, nilotica-crucian, and other species. Using the energy of geothermal waste water can assist in attaining a highly economic output of such cultures, which is shown by the following descriptions for culturing turtles.

2. Advantages of using geothermal heat for turtle culture

Our studies showed that, by raising the temperature of turtle ponds to between 25 and 30°C, young turtles reach mature weights between 14 and 16 months after hatching whereas turtles grown in natural conditions (with annually fluctuating pond temperatures) take from 4 to 5 years to reach the same weight. In natural conditions, turtles can lose 10 to 15% of their body weight when adopting a dormant stage in winter, whereas turtles raised in controlled, tepid ponds do not hibernate, and put on weight throughout the year.

Turtles growing in geothermally-heated ponds at constant temperature also forage more efficiently than those growing under natural conditions. Our experiments, listed in Table 1, show that an optimum water temperature for turtle culture is about 30°C, when they gain a maximum in weight. The tests in Table 1 are based on a feeding time period of 31 days. Although in the absence of geothermal waste heat the temperature of the turtle ponds can be maintained by a small boiler plant, fuel costs reduce economic benefits, and fossil fuels also add to atmospheric pollution.

TABLE 1: Increase in weight of turtles raised in different pond temperatures and effect on forage coefficient.

Temperature of pond ("C)	20	25	30	35
Forage coefficient	4.4	2.5	1.5	2.5
Gain in weight (g) during testperiod	0.4	2.2	10.3	6.6

Elevated, constant temperatures of turtle ponds (i.e. 25-30°C) also increase the rate of incubation from 30 to 50% under natural conditions to about 90% in tepid pools. The rate of survival of newly-hatched turtles also increases from 30-40% in natural conditions to about 80% in heated pools. Hence, geothermally-heated ponds provide a better control for breeding. The higher survival rate of turtles raised under controlled breeding also reduces the need to catch turtles in nature to maintain breeding stock, and puts less pressure on the environment.

3. Technical details of controlled turtle culture

Best results in turtle culture can be achieved if the following points apply:

(a) The ponds should be in the vicinity of a large supply of geothermal (waste) water; the

TABLE 2 Recommended population density per body weight per square metre of pond

Weight (g)	5-50	50-100	100-200	200-400	500	1000
Population per sq m	15-30	10-15	8-10	6-8	0.5-1	0.3-0.4

TABLE 3: Effect of temperature on hatching period

Hatching temperature ('C)	Relative humidity (%)	Hatching period (days)	Incubation ratio (%)
25	83	61.8	90
28	85	54.4	92.5
33	68	45.5	90

TABLE 4: Effect of protein content of forage on weight gain in newly-hatched turtles

Protein quantity (%)	40	45	50	55	60
Weight gain (g) (for same test period)	14.1	20.7	25.5	16.3	12.0
Forage coefficient	2.3	1.8	1.45	1.95	2.6

TABLE 5: Annual production costs of a turtle culture (figures in Chinese yuan) per mu pond area

Initial costs of baby turtles (and breeding stock)	Forage	Wages	Water & electricity	Depreciation, land rental, other costs
40,000 - 50,000	10,000-15,000	3000	3000	5000

Total production costs per mu:	61,000 - 76,000
Value of turtles sold:	150,000 - 160,000
Less business tax:	15,000 - 20,000
Profit:	70,000 - 80,000

water and the make-up water has to be of good quality and should not contain any pollutants. (In the case of polluted or highly mineralized geothermal water, the make-up water should be heated by a simple heat exchanger.) The ponds should be in a quiet environment, and be exposed to the south (in China).

(b) Turtle cultures require different pond sizes depending on age. A pond area of about 50 m^2 is sufficient for newly-hatched turtles; ponds for adolescent turtles should be about 300 m^2, those for mature turtles should be about 500 m^2 and ponds for breeding about 600 m^2. Good temperature control of pond water is especially important for the ponds with newly-hatched and adolescent turtles.

(c) Feed supply should be adjusted to body weight, and turtles in a given pond should always be of a similar size since larger turtles can oppress smaller ones, affecting their growth. The number of turtles that can be kept in a pond of a given size depends on the body weight. The density of population as a function of size is listed in Table 2.

(d) For optimum breeding, a good parent stock should be selected. Hatching of eggs produces good results if it takes place in an artificial incubation room at constant air temperature and constant humidity. Results of our hatching experiments are given in Table 3, and show that hatching at 33°C can reduce the hatching period by 2 weeks (the success rate of hatching - i.e. incubation ratio - appears to be independent of temperature in the range 25 to 33°C).

(e) For best growth, turtles require a protein-rich diet containing traces of minerals, some starch and other ingredients. Maximum growth of baby turtles requires about 50% protein in the diet, as shown by our experiments listed in Table 4. The optimum amount of protein produces maximum weight gain.

(f) Water quality in the pond must be maintained continuously. It should never become dirty, particularly in smaller ponds. The temperature should not change by more than 5°C. For bigger ponds, the water should be changed once every 5 to 7 days.

(g) Turtles become sick if they are wounded or injured when producing or carrying eggs. To prevent diseases from spreading the pond should be sterilized with disinfectant, and sick turtles should be kept separate from healthy turtles until they have recovered.

(h) We found that turtles in culture ponds mix well with some species of fish, e.g. nilotica crucian and silver carp, stocked at 1 to 2 fish per square metre. The fish utilize any surplus food, thus keeping the pond clean. Turtles swimming in ponds with fish increase the oxygen content of the water and this, in turn, raises the utilization ratio of forage for both species.

4. Economic analysis

Turtle culturing requires a high investment but also provides a rapid economic return. Based on conditions which are typical for Fuzhou, we found that investment costs per one Chinese mu (666 m^2) of turtle ponds are about 70,000 to 80,000 yuan (8 yuan = $1 US when this paper was written). Under optimum management, turtle culture an return about 150,000 yuan per year per mu area, thus the investment outlay can be recovered within a year. Using geothermal waste water at Fuzhou, the annual production costs per unit area (1 mu) are those as summarized in Table 5. Higher investment costs for longer pipelines transporting geothermal water would increase the production costs, but these could be recovered by increasing the size of the whole enterprise.

5. Conclusion

Although utilization of geothermal waste water has been described by using it for fish farming and soil warming, the economic return for using it in turtle culture appears to be very attractive for China if turtle growers consider the points discussed in this paper. It is also anticipated that this aquacultural utilization of geothermal energy reduces depletion of naturally growing turtles.

6. References

Our findings have been published in Chinese in the following articles:

GAO, S.Q. (1990): Geothermal utilization in aquaculture and its development in Fujian Province.
GAO, S.Q. and LIN, B. (1992): Turtle culture with geothermal water and effects on production.

Upon request these publications can be made available by the authors.