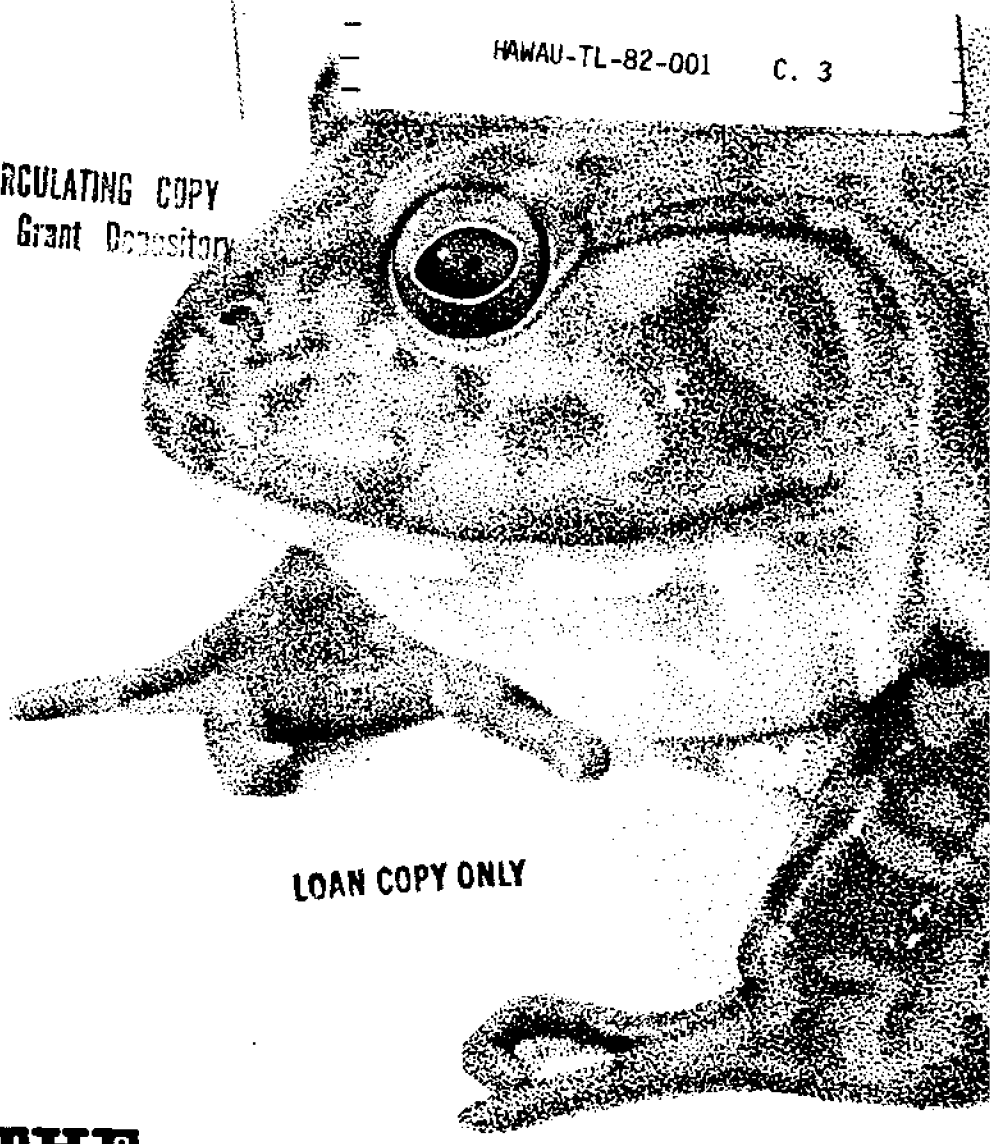

THE FEASIBILITY OF MASS CULTURE OF THE BULLFROG IN HAWAII

A PRELIMINARY EVALUATION

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INTRODUCTION

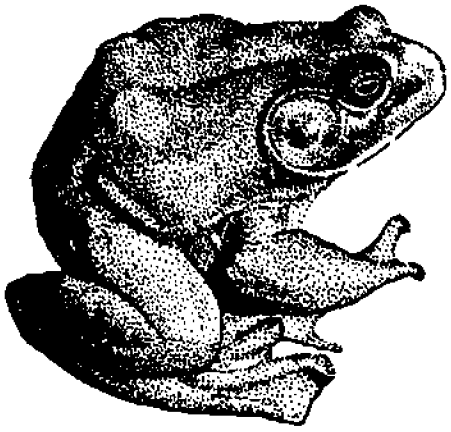
In 1970, Louisiana State University's Agricultural Experiment Station, with support from the National Institutes of Health, began a research program to develop techniques and facilities for the laboratory and commercial culture of the bullfrog (Rana catesbeiana). In 1975, this effort was joined by the LSU Office of Sea Grant Development. The project is still continuing, but sufficient knowledge is available to design a full-scale production system and an economic evaluation can be obtained.

This publication, sponsored by the Sea Grant College Programs of Louisiana State University and the University of Hawaii, provides a preliminary evaluation of the feasibility of establishing a commercial bullfrog culture system in the state of Hawaii. Hawaii has an excellent climate and a proven supply of living food, which is required by the bullfrog. The successful culture of two topminnows, Poecilia vittata and P. mexicana, removes a major constraint on the cultivation of the bullfrog. It was the work of Wayne J. Baldwin in developing techniques for the culture of these topminnows that led to the consideration of bullfrog culture in Hawaii. This paper also provides a basic guide for bullfrog culture in other parts of the world, and includes criteria for the preliminary evaluation of sites, markets, and estimates of operational costs.

There is no doubt that universities can develop laboratory colonies of bullfrogs for research, as the culture system is workable if procedures are followed properly. A concentrated effort is being made to control diseases, a major concern at present, but, even so, the rate of mortality is no greater, in many cases, than that of domesticated animals. Most bullfrog mortality occurs in the early, larval, stages of development; however, because of the large number of eggs released by a female, sufficient animals can be produced to offset the losses if ample broodstock and appropriate support systems are established.

The question of marketing must be resolved. The evidence of a market for human consumption is apparent, but the culture system may not be cost-competitive with the collection of wild bullfrogs. The market for research and teaching, associated with universities, medical schools, and various other institutions, appears cost-competitive, but capturing the market depends on wise management and effective sales promotion. The availability of wild bullfrogs, widely used for teaching and research in the past, has declined greatly. As a result, many teachers and researchers have shifted to other species of frogs. The question is,

how much of this market can be recaptured?



Assuming a well-designed marketing program, there are several factors that favor recapture. (1) The bullfrog is widely accepted in research and teaching. (2) Except for one other species of frog, the bullfrog is the only species clearly ready for commercial production at costs competitive with the use of wild amphibians. The other species under culture, Xenopus laevis (African clawed frog), is exotic to the U.S. and has not been completely cleared as a new introduction. It may be possible to market the bullfrog at prices lower than the current retail prices for Xenopus, but, if not, there is ample room for both species in the teaching and research market. (3) The cultivated bullfrog can be available all year, an invaluable aid to researchers and teachers who are frustrated because of the difficulty in obtaining frogs when needed. (4) The cultivated bullfrog will be a research animal of high quality compared with wild-caught frogs, an advantage for research projects. In essence, the researcher will obtain an amphibian that is healthy, has a known history, has been maintained on an adequate diet, is adapted to laboratory conditions, has a known age, and has been treated for disease. These factors are strong points for marketing the bullfrog.

THE CULTURE SYSTEM

As presented here, the proposed culture system assumes the production of 120,000 frogs per year, with a monthly sale of 10,000. Larger or smaller units can be developed, but the economic analysis would differ with the size of operation.

Several major facilities are required to raise bullfrogs: brood ponds and rearing ponds for the production of a suitable fish to feed the frogs; culture tanks for hatching bullfrog eggs and raising the larvae; and a building or roofed area to hold the growing frogs. In addition, space is needed for office work and for such activities as processing larvae feed, stimulating females for reproduction, storing equipment and supplies, and processing and packaging orders. Breeding ponds for bullfrogs are also needed as an adjunct to the hormonal stimulation of breeding.

Daily activities include collecting fish to feed the frogs. To simplify feeding, a supply of fish sufficient for several days can be collected and held adjacent to the frog-culture system. The frogs should be fed daily and their containers washed down twice a day, or once a day if a continuous flow of water is used in the containers. The cleaning can be either automated or manual. It is mandatory to inspect the frogs daily for signs of disease.

As young frogs develop, they require larger fish as food. During the first month of the frogs' growth, the fish they are given should be 1.5 to 2.0 cm in size, but by the third month, the frogs are capable of consuming fish from 3 to 4 cm. Because the fish-culture system requires this size gradation, it is desirable to maintain two holding facilities at the frog-culture area for fish of various sizes or to have nets or graders to sort out the fish. Grading may be accomplished by placing screens with graded mesh in the holding tanks within the troughs where the frogs feed.

The frogs should be confined on the floor of their building. To prevent the spread of disease, it would be wise to divide the space into compartments of 100 to 200 sq ft each, with about 1500 to 3000 frogs per compartment (see Table 2). The area should be designed for rapid drainage and also include dry surfaces. The lower end should have a shallow trough for holding the fish in flowing fresh water. The water level in the fish trough should not exceed 1.0 cm, sufficient to keep them alive but prevent them from swimming. The compartment floor should be neither abrasive nor

slippery, but textured to provide footing. Slippery surfaces cause frogs to pull themselves about with their forelegs, resulting in reduced muscle development in their hind legs.

Frog larvae must be attended daily. They should be maintained in wire-framed baskets suspended in flowing fresh water to prevent the buildup of waste contaminants and to facilitate the removal of growth inhibitors. Because larvae feed frequently, food must always be present.

The larvae diet can be prepared at the facility and should include a balanced mixture of animal and plant proteins, carbohydrates, fats, vitamins, essential elements, and a food preservative. The diet should contain 25 to 30% solids bound with agar (2% of solids by weight). Larvae food can be refrigerated for two to three weeks. Food conversion for larvae averages about 1.5 on a wet-weight basis. Ten thousand larvae, averaging 10 g at metamorphosis, consume about 330 lbs of feed over a period of eight to ten weeks.

At metamorphosis, when forelegs emerge, young frogs should be removed or allowed to move from the container into the frog-rearing area. They begin to feed when their tails are absorbed.

During metamorphosis, mortality can be quite high if the larvae have not been maintained under sanitary conditions, in water of good quality, with adequate nutrition, and without excessive stress. Fortunately, crowding does not appear to cause stress if the system is otherwise optimal. Larvae can be maintained at densities of up to 15 per liter. Flow rates should allow for a complete water exchange every six to eight hours.

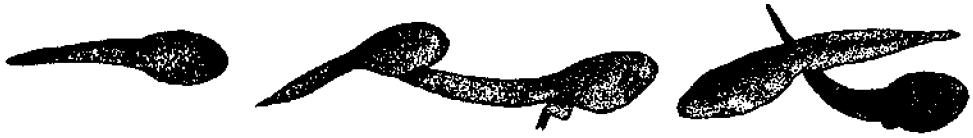
Each month eggs will be obtained through the artificial breeding of adults in the culture facility, insuring a continuous supply of animals. Breeding techniques have been worked out, but in the event of failure during one month, or the high mortality of the larvae (most likely to occur at hatching or during metamorphosis), it is wise to institute an alternative culture system. Outdoor earthen ponds or lined pools in which natural breeding can occur or artificially spawned eggs can be placed can fulfill this need. As the larvae approach early metamorphosis, they can be collected from the ponds or pools, placed in the rearing system, and fed the prepared diet. These alternative systems must be managed as if they were an integral part of the culture facility.

Each month about 13,000 larvae must successfully complete metamorphosis. Although mortality in young frogs may not exceed 10%, allowance should be made for 25% mortality, with the production of 10,000 new frogs each month. Two females should easily provide up to 20,000 eggs, but four females should be available for ovulation each month. Thus, a minimum of 50 mature females should be maintained, with another 20 in holding ponds and pools. The same number of males should be available to provide ample sperm for fertilization of the eggs

Ovulation in the females requires bullfrog pituitaries and progesterone. Spermiation in males requires LH/FSH-RF, which, like progesterone, is commercially available. The pituitaries can be obtained from either cultivated or wild-caught bullfrogs and, as no more than 200 to 300 pituitaries are required annually, there should be no difficulty in obtaining them. Techniques for the extraction can be easily learned and storage requires only refrigeration in acetone. A long-lasting RF (releasing factor) has been developed and successfully used to produce ovulation in females, but it is not yet commercially available. Should this new material continue to perform as well as early tests indicate, bullfrog pituitaries will not be needed.

Growth rates vary among frogs, and some reach the desired market size sooner than others. When preparing for live shipment (teaching and research markets), therefore, the animals may be selected from several containers. Shipping the animals creates an entirely new and stressful environment, but because they are handled daily, they are adapted to a variety of stresses and, unless mishandled during packing and shipping, should arrive at their destination in a healthy condition. Shipping of live animals should be accomplished within 24 hours. This is possible from Hawaii if specific receiving locations are established (discussed later). The animals are placed in wax or plastic-lined perforated cardboard boxes for shipment. The boxes are filled with a synthetic chopped foam material used as a filler for pillows. The material is moistened and excess water removed. The moistened packing material prevents dehydration, holds the frogs in place, and provides insulation from fluctuating temperatures. Among the many frogs shipped from the LSU facility, mortality is rare, whereas among wild frogs, 50% mortality in shipping or shortly after arrival is not uncommon.

In summary, there is no serious doubt about the feasibility of mass bullfrog culture. The techniques are well enough defined, and if alternative methods for breeding and larvae culture are installed, a commercial operation is possible. Hawaii is a suitable site for bullfrog culture, primarily because of its climate and its abundant topminnow production.



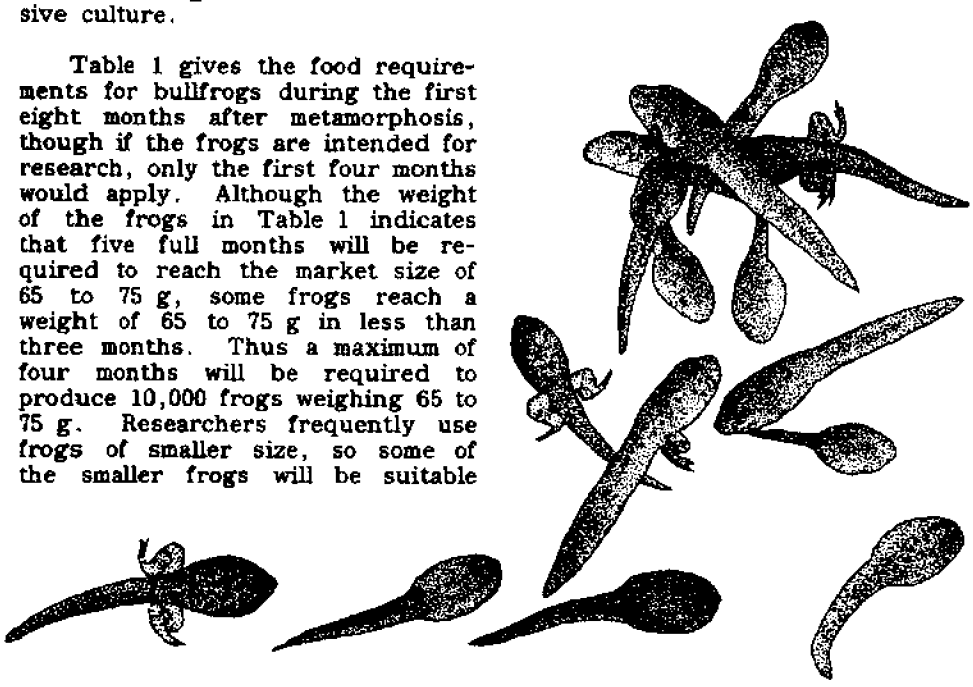
SPACE, FOOD REQUIREMENTS, & PRODUCTION

As described by one of the authors (Baldwin, see bibliography) topminnows can be reliably cultivated to provide a continuous supply of food for the bullfrogs. The production of 8000 lbs (3628 kg) of topminnows per acre (0.4 ha) is a conservative figure, but it will be used throughout this paper for calculations. The basic unit of frog production is 120,000 frogs per year, marketing 10,000 frogs per month.

For the research market, the system is designed to produce frogs weighing 65 to 75 g within four months after metamorphosis, even though smaller frogs can be used. The market for frog legs in the U.S. requires frogs weighing 200 g (0.44 lb), which can be produced in seven to nine months. These growth rates have been achieved with wild frog stocks under intensive culture.

Table 1 gives the food requirements for bullfrogs during the first eight months after metamorphosis, though if the frogs are intended for research, only the first four months would apply. Although the weight of the frogs in Table 1 indicates that five full months will be required to reach the market size of 65 to 75 g, some frogs reach a weight of 65 to 75 g in less than three months. Thus a maximum of four months will be required to produce 10,000 frogs weighing 65 to 75 g. Researchers frequently use frogs of smaller size, so some of the smaller frogs will be suitable for sale.

A full production of 40,000 research frogs (10,000 each, at ages one through four months) requires 101 pounds of food per day. If, however, the intention is to raise frogs for human consumption, full production is 80,000 frogs, and 483 pounds of food are needed per day. Research animals (120,000 per year) require 36,865 pounds of food; those for human consumption, 176,295 pounds of food. To produce 8000 pounds of fish per acre per year, five acres are needed for the research frogs and 22 acres are required to feed the frogs intended for human consumption. Even though fish production could be well above 8000 pounds per acre, some loss must be expected, and, to be safe, the acreage should be doubled to insure



an abundance of fish. Thus, we recommend 10 acres of fish ponds to feed research frogs and 44 acres to feed those for human consumption. Another two acres should be set aside to contain breeding ponds for the frogs and fish and extra space for buildings and roads.

Table 2 shows the breakdown of space required to cultivate bullfrogs ranging in age from one to eight months postmetamorphosis. It is obvious that the capital investment will go up considerably if the frogs are to be raised for the human consumption market, as the space requirement is more than double that needed for frogs for the research market.

In many locations, a covered concrete slab with screened walls is sufficient to house the frogs; the cost of such a structure is about $30 per sq ft. In locations where the air temperature drops below 70°F (20°C) and the water source cannot be used to help maintain the temperatures in the culture area, or in areas where high winds are frequent, an enclosed, insulated metal building is required. The cost for such a structure is approximately $40 per sq ft. Space for an office (200 sq ft), holding broodstock (100 sq ft), larvae culture (200 sq ft), work space and storage (600 sq ft), and a restroom (100 sq ft) requires an enclosed structure. A trailer could provide an office, storage space, and a restroom, thus reducing building costs.

The selective breeding of frogs for rapid growth (a project currently underway at Louisiana State University) may produce frogs with growth rates at least double those of wild bullfrogs. Some parents used in the breeding program attained a weight of 450 g (one pound) only four months after metamorphosis. If this selection process is successful, research frogs could be produced in six to eight weeks after metamorphosis, and those for human consumption in 12 to 16 weeks. Such growth rates require higher daily rations of fish, which will require greater fish production in the ponds or additional ponds. Holding space for frogs remains the same. Unless more frogs can be sold, however, the economics of raising these faster-growing frogs may not be favorable.

SITE SELECTION

General Considerations

The choice of location for the culture of bullfrogs should consider such factors as climate; water availability and quality; the availability of land and the terms of its purchase or lease; the proximity of air transporting facilities; the availability of professionals as employees and as advisors; the adequacy of the local labor force; the adequacy of food supply; legal constraints; the cost of construction; market access; and topography. In order to keep costs as low as possible, site selection must be undertaken with care.

Location

A location suitable for bullfrog culture should have sufficient land for the anticipated expansion of topminnow production. In addition, the topography should allow the flow of water from the topminnow ponds to the bullfrog culture facility. The ability to move the topminnows into the culture building by flowing water would be a distinct advantage, as it could reduce labor costs, the loss of fish, and the need for levee road maintenance.

In choosing a site for a culture facility, the use of existing aquaculture systems should not be overlooked, as they may already include the necessary water, land and ponds, some buildings, and experienced personnel. The ponds often contain a variety of forage fish, in which case a special culture system for fish may not be required

Water

Areas that can provide sufficient water for other forms of aquaculture are also suitable for bullfrog culture, as bullfrogs do not need large amounts of water The culture of topminnows requires the greatest quantity of water, but in certain locations, brackish water can supplement the freshwater supply, as topminnows can be cultivated in brackish water. To reduce the use of water further certain stages of the bullfrog larvae can be placed in the same pond with the topminnows.

Care should be taken in selecting the water source, as treatment to correct its chemical makeup would increase costs. For the culture of larvae, water pH should

be between 6.5-7.0, if possible, and preferably not above 7.5.

Surface and groundwater quality in Hawaii is acceptable but site specific. Surface waters generally have a pH of 6.8-7.2, and fresh rains usually have a pH of less than 7.0. Shallow groundwater pH normally varies from 7.0 to 7.5, occasionally reaches 8.0, and, if close to pineapple crops, decreases to 4.5 for specific conditions. Deeper groundwater (basal) usually has a pH from 7.0 to 8.0. The Port Allen area pH ranged from 7.2 to 7.9 (a desirable range for a culture facility) and the Honapepe River in the area, 6.9 to 7.7. In accordance with current knowledge, calcium as calcium carbonate should not be less than 50 mg/l. Although larvae have been cultivated in water without calcium, their diet apparently contained sufficient calcium. Dietary calcium needs are poorly defined, so it is safer to use a source of water with calcium. Water hardness in the deeper strata is about 60-80 mg/l calcium as calcium carbonate (about 25 to 30 mg/l calcium). Shallow groundwater has somewhat less calcium.

Water temperature should not be below 20°C nor above 26°C at any time. Groundwater is preferable to surface water for washing down the frog culture area but not essential.

Total solids around 200 mg/l, with most as sodium chloride, are within acceptable limits. Trace minerals are required for the larvae and frogs, but quantities have not been established. These minerals are present in variable quantities throughout Hawaii, but are also available in the frogs' diet.

Climate

Locations with low rainfall are desirable, as there would be fewer problems associated with working outdoors and road maintenance. Areas that are sheltered from high winds (above 40 mph) are preferable, because construction costs for the frog-rearing facility could be reduced. Lightweight roofing, or even nursery shading materials, could be used in areas with low winds.

Personnel

In Hawaii, professionals for employment and as advisors are available, and there is no shortage of labor. Although no professionals were located with expertise in the culture or managment of amphibians, the techniques were easily learned.

Legal Constraints

In cultivating bullfrogs in Hawaii, only one legal constraint was found. A law established in 1919 prohibits the collection of tadpoles and the exportation of bullfrogs shorter than nine inches (legs may not be shorter than four inches). This law must be changed because of the size of the frogs recommended for culture. Laws governing the importation of exotic animals to Hawaii represented no problem, as the bullfrog is established in Hawaii; but it has not been determined whether the animal inhabits all the islands.

COST & REVENUE BUDGET

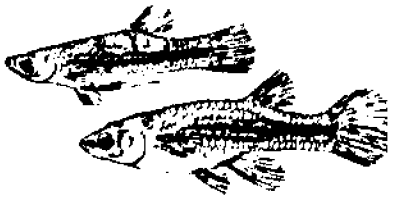
Table 3 shows the breakdown of costs for the culture system. The two variable costs in producing frogs represent 80 percent of the total high cost and 58 percent of the total low cost. The difference is caused by variable land costs. A land lease agreement of 4 percent of gross sales necessitates incorporation of land costs in the variable cost section of Table 3. The low-cost estimate treats the land charge as an opportunity cost of land owned by the frog culturist. Consequently, the value of the return to the culturist's investment is cited as a cost ($.30 per frog) in the overhead section of Table 3 (see footnote o).

A culture system takes more than a year to establish, and cash and capital expenses are incurred before marketable frogs are produced. Thus, the estimates in Tables 3 and 4 reflect a system in operation and not a cash flow analysis. It is a snapshot, so to speak, of a year's operation.

Topminnow production and personnel costs are the most expensive variable costs, and it would be advantageous to control them. If aquaculture ponds already exist, along with suitable buildings, a well, and other necessary components, the cost could be lower than reported here. Little reduction in personnel costs could be expected in the U.S., but in other countries with lower wages, some savings could be possible.

The cost of land per acre is higher in Hawaii than on the U.S. mainland, and so Table 3 estimates land rental at 4% of gross sales in Hawaii. With frogs selling for $2.50 each, land rental would be $1000 per acre. Land rental per acre on the U.S. mainland should not exceed 25% of the Hawaiian high-cost estimate. The low-cost column of Table 3 would also be reduced to reflect a reduced opportunity cost. With land at $5,000 per acre on the mainland, the opportunity cost per frog would be $.138. This estimate incorporates a 50% reduction in minnow productivity on the mainland. Thus, 20 acres of land are needed there for minnow production but only 10 acres in Hawaii. With mainland production, the total low cost would be $1.37 per frog, as compared with $1.53 in Hawaii.

It is evident from the calculations in Table 4, that a considerable cost overrun could be tolerated. Note that since the cost of leasing land is a percentage of gross revenue, the high production costs vary with each column. If produced in Hawaii, the high break-even price for wholesale research frogs is $1.74 per frog and the low break-even price is $1.53 per frog.



Wholesale prices for wild-caught bullfrogs on the U.S. mainland range from $1 to $4.25 each, depending on the size of the frog. The lowest retail prices start at about $4 for a three- to four-inch frog (60 to 100 g) and go to $10 for frogs over seven inches (at least 600 g). Special orders, such as shipments composed only of females, increase the price by 10%.

Cultivated bullfrogs should command higher prices than wild frogs because their value in research is far superior to that of wild frogs; their mortality is lower (about 5% compared with an estimated 50% for wild frogs from the time of capture to use); they can be maintained easily for extended periods; and useful information can be supplied with cultivated frogs (such as age, geographic location of parent stock, diet, conditions of culture, and medication).

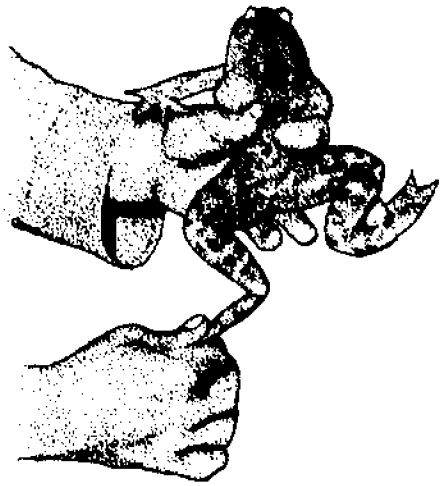
At Louisiana State University, the amphibian research program sells unneeded frogs produced in the facility. Wholesale prices range from $2 for a 30-gram frog to $10 for a 200-gram frog. Frogs weighing from 60 to 90 grams should easily command $5 from researchers. These prices are acceptable not only for the aforementioned reasons, but because the animals can be supplied all year. This is significant because it allows researchers to conduct studies year-round.

Two suppliers of wild bullfrogs were consulted during this study. Together, they sell about 75,000 live bullfrogs a year and can identify sales for another 75,000 without advertising. The market potential is much larger, as an estimated two million live frogs (about four species) are used for research, and an estimated eight to ten million are used in teaching. Cultured bullfrogs would be suitable as a replacement in many cases, but a serious marketing effort may be required.

At present, only one species of amphibian is commercially cultured and marketed as a research animal. This frog, Xenopus laevis (African clawed frog), is widely used in research and teaching and is gaining in popularity, as it is available all year. The biggest drawbacks to using Xenopus are its long maturing time and high price. The larvae sell for $.50 each (an acceptable price), but the newly metamorphosed frog (one-inch body) costs $3.25. These frogs must be reared for several months to reach maturity and the mature adults sell for $13 each. Our cost estimate indicates that the bullfrog can be provided at a lower price.

The leopard frog (Rana pipiens complex) is widely used in teaching and research. Like the bullfrog, it is not mass cultured, and there is little evidence that mass culture systems will be established in the near future because the supply of wild leopard frogs is fairly good and prices are acceptable. Leopard frogs (30-40 g) smaller than the research-sized bullfrog (60-75 g) sell for $1 to $1.40 ($1.50-$2.10 in winter). Leopard frogs as large as or larger than the marketable bull-

frog (60-75 g) sell for $3 to $4.15 ($5.40-$6.50 in winter). These are all wild-caught animals and exhibit the same poor health and high mortality as wild bullfrogs. If one considers the number of leopard frogs dead on arrival (or dead within a few days of receipt), for which no reimbursement or replacement is obtained, the cost per leopard frog may exceed that of the cultured bullfrog. When all factors are considered, a cultured bullfrog of high quality may be cheaper to market than wild-caught leopard frogs and bullfrogs.



Current sales of bullfrogs are no indication of the demand but reflect a supply deficiency. Some large biological supply houses, which at one time enjoyed excellent markets, no longer offer live bullfrogs in their catalogs. Their sales of bullfrogs exceeded by a considerable margin those of the two suppliers mentioned earlier. A major problem encountered in producing bullfrogs for the research market in Hawaii was that of establishing contracts to guarantee large shipments to the mainland. Small orders of 10 to 500 frogs, as frequently purchased by universities and individual researchers, are prohibitive because of high shipping costs. In addition, bookkeeping requirements increase greatly, contributing to a higher production cost. Thus, a successful effort would probably require a strong sales management plan and firm contracts with buyers who can receive several thousand frogs at a time.

MARKETING FOR HUMAN CONSUMPTION

Sales of frog legs (imported from Asia) to restaurants on the U.S. mainland are estimated at about $60 million annually. Six million pounds of legs represent about 18-24 million frogs. Import figures vary greatly from year to year, but there are indications that the numbers are declining (Table 5). The restocking programs in some Asian countries and in Mexico provide evidence of a decline in wild frogs.

At today's wholesale prices to restaurants in Hawaii (up to $6.10 per pound of legs, representing three to four frogs) each pair of legs is costing the restaurant owner $1.50 to $2.03. One or more of the following changes must take place before the sale of cultured bullfrogs for human consumption can be considered:

(1) The supply of natural frogs must decline greatly.

(2) Prices must increase.

(3) Smaller frogs (about 150-200 g) must be acceptable.

(4) A market must develop for the organs and glands (such as the heart, brain, liver, pituitary), the backs, and the skins.

(5) Production costs must be reduced (see Table 3).

(6) Frog legs must be offered as appetizers as well as regular dinners (thus reducing the serving size).

Item 1 is a distinct possibility, as laws restricting capture are increasing; the contamination of frogs with toxic chemicals is not uncommon; and improper processing and storage have caused the rejection of shipments from Asia to the mainland. One or a combination of these factors may severely reduce the supply of legs taken from wild frogs.

Items 2 and 3 are difficult to bring about, even though the desirability of smaller legs was mentioned by several wholesale suppliers and restaurant owners. If restaurants offered the legs in smaller portions, such as in appetizers, it would, in effect, allow the culturist a higher price per frog (item 6). However, to produce a frog weighing 200 g (yielding about 60 g per pair of legs, or slightly over two ounces) would require eight months. Food cost for the frog alone would increase $.80 over the lower cost in Table 3, as it would take 600 g of food (1 1/3 lb) to produce a 200-g frog. The increase in building costs would be $.11 per frog because of the additional space required to hold the frogs eight months. There are also the costs associated with interest on equity capital; debt and opportunity-cost capital invested in land; and the cost for processing the legs. The cost to the culturist per frog would probably approach $3 and it would take eight 200-g frogs to yield one pound of legs (454 g). Thus, a pound of meat would cost about $2 to produce, or $1.50 per leg.

Item 4 shows some promise. For example, Rana pipiens pituitary glands, which are used widely in research and teaching, sell at retail for about $1.25 each, and the

bullfrog pituitary should sell for about the same price. The culturist could expect to get about $.50 for the gland from a biological supply house, or $.15 for the head, which contains the pituitary. The marketing of other parts of the animal requires the development of both product and buyers. The skin should be useful as a tanned product, but a process for tanning is at present unknown. Although the back and forelegs contain only 5% meat, they might be useful in providing a stock for prepared soups or sauces to go with the legs at restaurants. The carcass could probably be used as a food supplement for prawns.

Reducing the cost of production, item 5, is certainly possible. The most obvious area for reducing costs is in the production of topminnows. If land is owned, and ponds and buildings available, there could be a considerable reduction. Paring costs for personnel is unlikely in Hawaii or on the mainland, though in other countries, this could be a factor.

Wholesalers and restaurant owners in Hawaii resisted paying higher prices, but if frog legs of consistent good quality are to become a regular item on menus and in the market place, higher prices are required. Two markets were identified on the U.S. mainland, where higher prices are paid. Certain ethnic groups purchase only live frogs, at $4 to $6 per frog. The extent of this market is unknown, but the user consumes not only the hind legs, but the front legs and the back as well.

A biological supply house on the U.S. mainland markets extra frogs at prices ranging from $2.75 to $3.15 per pound of live frogs, which equals $9.08 to $10.40 per pound of legs. The demand reportedly exceeds the company's supply. A half-pound frog would bring an average price of $1.47, a marginal price, as shown previously.

In Hawaii, wholesale suppliers indicated that the demand for legs in Hawaii was sufficient, but not well defined. They expressed a greater interest in fresh rather than frozen legs, as frozen legs brought lower prices and were subject to freezer burn. Freezer burn was confirmed on the U.S. mainland, as frozen legs were frequently reported to be in storage over one year. However, the Hawaiian export market to the mainland was well organized, and, according to two wholesalers, the supply was steady. Prices to restaurants on the mainland ranged from $1 to $3.15 for one pair of legs. Sales were best to the more expensive restaurants. One wholesaler indicated an interest in receiving 400 pounds of legs a week, but would pick them up only if he were en route to getting other supplies; there was a general reluctance to make special pickups of frog legs alone unless the poundage was much greater.

All indications are that the demand exists and that the animals can be cultivated, though the current price of frog legs for human consumption does not appear to justify a culture effort. Unless prices increase and the supply of wild frogs declines, the culture of bullfrogs for human consumption must be viewed cautiously.

SUGGESTIONS & COMMENTS

State Hatchery System

A state hatchery system for bullfrog larvae would reduce the costs of the culturist's facility requirements. In addition, well-trained personnel would be associated with the culture effort and would undoubtedly be able to deal more effectively with disease problems. A state hatchery could also serve as a training and information center for culturists who desire to develop their own larvae culture systems.

Human Health Problems

The possibility that frogs would transmit diseases to people would be no more of a problem than with other aquaculture activities. With the proper sanitation practices and common sense, few, if any, health problems should occur.

NEEDS

Before a full-scale culture effort is undertaken in Hawaii, several short-term studies should be made. Similar studies should also be carried out in any other area where the establishment of a bullfrog culture system is being contemplated.

1. Tests should be conducted to determine how well the frogs grow and develop when feeding on topminnows, particularly topminnows cultured in saline water.

2. The culture of frog larvae in water with low salinity (7-10% seawater) should be studied. Is such culture possible? Can it be integrated with topminnow brood ponds, and will disease problems be reduced?

3. Are the bacteria associated with topminnow diseases of the same species as bacteria associated with bullfrog larvae diseases?

4. In the event that the pituitary glands needed for reproductive control cannot be purchased, are there sufficient wild stocks of bullfrogs in Hawaii to provide the glands? (Even though the frogs can be cultured at the facility, a supplement is desirable.)

5. Potential buyers of bullfrogs on the U.S. mainland must be identified and commitments obtained.

6. Efforts must be continued to ascertain the extent of the human consumption market in Hawaii and to establish an acceptable price structure.

7. Specific sites must be located to establish culture systems.

8. An economic analysis should be made to determine if it is more economical to utilize topminnows in bullfrog culture or to market them as baitminnows.

9. A method should be developed to harvest the topminnows easily, or, in the case where bullfrogs are cultured with a specie such as prawns, to work on a harvest system for easily collecting the various minnows from the prawn ponds.

ABLES

Table 1. Daily food requirements for frogs under culture for the research and human consumption markets.

Age of frogs[a]	Average weight per frog[b]	Percent of body weight consumed per day	Monthly average food conversion[b]	Average daily food consumption[c]	
0	5g	-	-	-	-
1	10	5	2.0	11 (lbs)	5.0 (kg)
2	22	5	2.5	24	10.9
3	35	3.5	3.0	27	12.2
4	50	3.5	3.5	39	17.2
5	75	3.5	3.5	58	26.3
6	105	3.5	4.0	81	36.7
7	140	3.5	4.0	108	49.0
8	175	3.5	4.5	135	61.2
			TOTAL	483	218.5

[a]Months postmetamorphosis; 10,000 frogs started each month with 10,000 harvested each month, 80,000 frogs under culture at full operation. Starting weight for new frogs is assumed to be 5 g but this ranges from 4 to 10 g and occasionally is higher.

[b]Average weight reflects the weight, for wild stock under intensive culture (based on data by Culley and Gravois 1971; Modzelewski and Culley 1974; and Culley, unpublished).

[c]Assumes no loss of fish during transporting or during feeding by frogs.

Table 2. Space requirements for bullfrog culture.

Age of frogs in months	Frogs per sq ft[a]	Total space (sq ft per 10,000 frogs)
1	15	667
2	12	833
3	10	1000
4	9	1111
		3611 Total for research frogs[b]
5	8	1250
6	7	1429
7	6	1666
8	5	2000
		9956 Total for frogs for human consumption[b]

[a]To convert to meters, multiply x 10.75 to obtain frogs/m^2.

[b]Add 1200 ft^2 to cover work space, office, storage.

Table 3. Costs of bullfrog production in Hawaii, using a base figure of 120,000 frogs per year for the teaching and research market on the U.S. mainland.

	Cost per 65-75 g Frog	
	High	Low
Variable Costs		
food production		
bullfrog food-minnow production	$ .37[a]	$.197[b]
larvae food[c]	.05	.02
disease control, hormones	.01	.01
advertising[d]	.10	.033
electricity	.02	.02
supplies, equipment[e]	.10	.10
land lease[f]	.12	---
waste treatment[g]	.01	.01
personnel ($40,000 per yr)[h]	.33	.33
employment taxes & fringes (@ 15% of personnel)	.05	.05
shipping containers & packing[i] materials	.04	.04
freight[j]	.12	---
interest on (½ operating[k] capital @ 15%)	.075	.075
Totals	1.395	.885
	(80%)	(58%)
Overhead Costs		
depreciation[l]		
truck (30% S.V.: $5600 ÷ 4 = $1400)	.01	.01
tanks (no S.V.: $20,000 ÷ 7 = $2857)	.03	.03
building (no S.V.: $192,000 ÷ 20 yrs-$9600)	.08	.08
interest on equity capital[m]		
(20% of $212,000 @ 15%)	.053	.053
interest on debt[n] (80% of $212,000 @ 15%)	.172	.172
opportunity cost capital[o]		
invested in land (15% on $240,000)		.30
Subtotals	.345	.645
Totals	$1.74	$1.53

Table 3. Continued.

[a]Includes land lease, construction, equipment, labor and manager, electricity, water, maintenance, interest, depreciation, food, and miscellaneous costs. Cost estimates per frog are based on $.75 - $1.20 per lb of fish, with $.75 per lb based on 180,000 lbs per year at 8000 lbs per acres per year's production. Higher yields per acres and design changes could reduce costs further.

[b]The low cost estimate excludes the land lease cost. Thus, it assumes owned land in minnow production.

[c]Larvae can possibly be cultivated with topminnow breeders.

[d]Advertising costs could vary greatly and be much higher if the marketing was aimed at the retail buyer of animals for teaching and research (universities). A minimum of $1000 per month would cover magazine advertising. Advertising costs should be reduced to about $4000 per year or less if the animals are marketed to wholesalers.

[e]Supplies and minor equipment include nets, seines, boots, plastic containers, refrigerator, sinks, hoses, pressurized air, chemicals, distilled water supply, glassware, syringes, hotplate, and microscope.

[f]Estimated at 4% of gross sales for the land associated with the frog culture. A percentage of gross sales going to the landowner would not be a cost factor if the culturist owns the land.

[g]Waste treatment costs are negligible, as rearing ponds for fish can be used as part of the treatment. Costs were figured at $1200 per yr.

[h]Fish production accounts for a manager and two laborers. Three other full-time workers are required (one professional at $20,000, two laborers at $10,000 each). Costs for fringe benefits are required. This assumes that the manager handles all office affairs.

[i]Frogs are shipped 25 per box. Minimum cost per box is $1.00, with 5000 needed each year for 120,000 frogs. Boxes for 100 frogs may be available. This cost includes absorbent foam chips to keep the frogs moist and styrofoam pellets to minimize their movement.

[j]The shipping of 2000 lbs (6000 frogs) from Honolulu is $.09 per frog to San Francisco, plus $.03 per frog if the culture facility is on another island. The cost from Honolulu to Chicago or New Orleans is $.14, and to New York or Atlanta $.16. The low cost estimate assumes an FOB price.

[k]Necessary annual operating capital was estimated at $120,000. The interest charge was calculated on one-half of the annual amount being oustanding on the average at an interest rate of 15%.

[l]Depreciation charges were estimated by deducting salvage value (S.V.) from acquisition cost, then dividing by the years of useful life. The truck cost was $8000, with a 30% salvage value after a useful life of four years. The tanks cost $20,000 with zero salvage value after a useful life of seven years. This $20,000 includes rearing tanks for the larvae at $15,000 and two fish holding tanks at $5,000. The building costs $192,000 with zero salvage value after a useful life of 20 years.

[m]An interest charge interpreted to be an opportunity cost on the equity capital (20% of $212,000 capital needs) was calculated using a rate of 15%.

[n]The interest charge on the principal (debt) of $169,600 (80% of $212,000) was calculated at 15%.

[o]Although opportunity cost is not a cash cost of frog culture, it is identified as a cost for comparison of investment alternatives. Twelve acres of land in Hawaii valued at $20,000 per acre, returning 15%, would yield $36,000 annually. This is equivalent to $.30 per frog.

Table 4. Gross and net revenue estimates for the production of 120,000 bullfrogs in Hawaii for the teaching and research market on the U.S. mainland.

	Wholesale		Retail	
Estimated selling price per frog	$2.50	$3.00	$5.00	$6.00
Gross sales for 120,000 frogs	300,000	360,000	600,000	720,000
Production costs[a]				
High: $1.73 each x 120,000	207,600	210,000	219,600	224,400
Low: $1.53 each x 120,000	183,600	183,600	183,600	183,600
Before tax net return				
Based on $1.73 cost per frog	92,400	150,000	380,400	495,600
Based on $1.53 cost per frog	116,500	176,400	416,400	536,400

[a]Land leased is a percentage of gross sales. The high production costs increase as the selling price increases. The low cost includes a fixed opportunity cost for land ownership; thus, the low cost will not change as selling prices change.

Table 5. The importation by the United States of processed frog legs from 1975 through 1980[a].

Year	Millions (Pounds)	(Kilograms)
1975	3.299	(1.299)
1976	6.515	(2.565)
1977	4.591	(1.807)
1978	7.343	(2.891)
1979	6.041	(2.378)
1980	3.876	(1.526)

[a]Legs are exported from Japan, Bangladesh, India, and several other Asian countries. Small quantities are imported from Mexico. Data from the National Marine Fisheries Service, U.S. Dept. of Commerce, Fisheries Market News Reports (1975-1980), New Orleans, La., USA.

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