species and production system. Abundant, high-quality water is usually the single most limiting resource. Land can be limiting if topography is not favorable for the construction of ponds, or if land is dedicated to other productive uses. Soil properties must be considered in pond construction, and soil fertility will influence pond productivity. Climate does not limit aquaculture, but does determine the species that can be grown (except in the case of the closed system aquaculture technology described below).

Production resources-capital, labor, and time- influence the choice of production system and species. Generally, the more intensive the production system (i.e. the more fish grown per volume of water), the more capital, labor, and time required. For example, lightly stocked farm ponds practically take care of themselves while closed systems need almost continuous monitoring.

Industry resources-including supplies, services, and markets-are well developed in some parts of the country for certain types of aquaculture. For example, in the Mississippi Delta Region, there are numerous catfish feed manufacturers, catfish processing facilities, and a strong producer association that supports marketing to promote catfish consumption. If aquaculture of certain species is less well developed in other parts of the country, the aquaculturists in such areas must be very resourceful. Producer organizations are valuable sources of information about markets and marketing.

In order for an aquaculture enterprise to remain viable and profitable, the operation must also be environmentally sound. Environmental issues, such as safety of fish and seafood; pollution of water by excess nutrients; destruction of coastal habitats; and damage to natural fish stocks by accidental release of farmed species, are major concerns for many consumers and need to be addressed by the aquacultural industry.

Technical resources, information, and expertise are critical to aquaculturists. Environmental and disease problems can develop quickly and threaten an entire crop. Quick access to professional diagnostic services such as fish disease labs can salvage an entire batch of fish. Contact your state Extension Aquaculture Specialist or other state or federal sources of information (see Further Resources for more details) about the programs and services available in your state or region.

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Regulatory Aspects

State or federal permits or licenses may be required of an aquaculture operation. The permit type will vary depending upon the species grown, culture techniques, local zoning ordinances, state and local water use and discharge regulations, and marketing strategy. Contact your state agencies concerned with environment, natural resources, and agriculture for more information on the requirements in your state. Your state Extension Aquaculture Specialist or state Fisheries Department may be able to assist you. KNOW THE LAWS THAT APPLY TO THE SPECIES UNDER CONSIDERATION. Without proper permits, interstate transport of a threatened or endangered species, or a species identified as an agricultural pest, is punishable by fine and/or imprisonment.

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Species

The main species being raised in the United States are: catfish, trout, salmon, crawfish, tilapia, and bait species. Catfish production is the largest part of the U.S. production with most of the production in Mississippi, Alabama, Arkansas, and Louisiana.

Coldwater species such as trout and salmon can be successfully farmed wherever water temperature does not consistently exceed 75° F. This usually limits production of coldwater species to northern states and mountainous areas, including the southern Appalachians, Ozark Highlands, Rocky Mountains, and Pacific Coast Ranges. Idaho, North Carolina, and California are the top three trout producing states and Washington and Maine are the largest producers of salmon. Coldwater species can also be grown anywhere adequate cold groundwater is available. Coolwater species, such as walleye, perch, sturgeon, and certain shellfish, tolerate warmer water than coldwater species, but their growth is inhibited at the warm, optimal-growth temperatures of warmwater species.

Warmwater species such as catfish, striped bass, paddlefish, and most shellfish need warm water over a relatively long growing season to be economically practical. Some tropical exotics such as tilapia die at water temperatures below 50° and so can only be grown during the warm months in most of the South or in thermal waters elsewhere.
Egg and fingerling production has emerged as a specialty operation in the maturing aquaculture industry. Hatchery facilities, especially in the South, can provide advanced fingerlings to more northerly producers with marginal growing seasons. Larval and immature shellfish are also produced in hatcheries. Hatchery techniques are complicated and have many special requirements; therefore, they are not recommended for the beginning aquaculturists.

Bait production is a very large component of the aquaculture industry in the United States. Louisiana, Minnesota, Florida, and Arkansas are all large producers of bait and ornamental species. Minnows, suckers, goldfish, and crayfish are some of the commonly grown bait animals. Sometimes bait species can be raised along with food species.

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Production Systems

Extensive aquaculture is conducted in ponds stocked at a low density that yield small crops, but require little management. Intensive aquaculture is practiced in artificial systems (ponds, cages, raceways, tanks), stocked at a high density that yield large crops, but require a lot of management.

Open systems allow water to flow through them without reusing the water. Generally, the more intensive an aquaculture system, the more water must flow through it. In open systems discharged water is lost from the system. Because water, as well as the cost to pump it, is becoming more of a limiting factor, technologies that reuse part or all of the water are being developed.

Closed systems recirculate and recondition all of the water used, largely freeing aquaculturists from water supply constraints. Closed systems have the potential to allow the production of almost any species anywhere, provided the market price can pay for the capital and energy requirements of the system.

Pond aquaculture is the most commonly practiced. Most large-scale aquaculture farmers construct levee-type ponds, but these require large amounts of relatively level land. Many small-scale and a few large-scale aquaculture farms use watershed ponds. Your local office of the Natural Resources Conservation Service (NRCS) will provide technical assistance for pond siting and construction. Cage culture, the growing of aquatic animals in floating or anchored net confinements, can be used in farm ponds or other existing water bodies that are otherwise unsuitable for aquaculture. Cage culture is often more compatible with other uses of the farm pond. Cages can be used to alternate warmwater and coldwater species in the same pond.

Tank culture, both open and closed systems, can be adapted to a wide range of species and situations. Tanks-made of steel, fiberglass, or plastic-can be dismantled and assembled for transporting or relocating. Advantages of tank culture include minimal land requirements, portability, and ease of expansion. Tanks can be located indoors to reduce climate limitations. High equipment cost, especially in closed systems, is the main disadvantage of tank culture.

Raceways-long, narrow canals with large flows-are the most widely used production system for the intensive culture of salmon, trout, and charr.

Polyculture, the growing of two or more species together, is rare in commercial U.S. aquaculture. This is partly because the species used in the sophisticated polyculture systems of Asia, e.g. various carps, are not well accepted as food items here.

Rotation systems, alternating aquatic and field crops, in levee-type aquaculture ponds can benefit both aquacultural and agronomic crops. Crayfish-rice and crayfish-rice-soybean rotations are commonly practiced, but other aquaculture-agriculture rotations have been largely neglected, even though there is much potential for beneficial rotation effects in such systems. Rotation benefits are similar to those seen in other agricultural systems: disease and weed suppression, reduced fertilizer and chemical inputs, and increased biodiversity (due to the mix of aquatic and terrestrial habitats in the landscape).

Integrated multiple use systems incorporating fish, livestock, fowl, and horticultural production over and/or near the pond are widely practiced in some parts of the world, but have been largely neglected in the U.S. The beneficial interactions between the different elements of this system help to reduce off-farm, purchased inputs.

Integrated aquaculture and hydroponics or aquaponics is a subject receiving increasing attention in the U.S. Beneficial interactions between aquacultural and hydroponics operations reduce some inputs, but such technologies are capital intensive. ATTRA can provide more information on aquaponics upon request.

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Marketing

Marketing strategy is one of the most important aspects of aquaculture. It is important to identify a reliable market and even a backup market, before making capital investments in aquaculture. Market price varies with the marketing strategy. Live fish sold directly to the consumer usually bring the highest price, but require much time and interaction with the public. Live fish sold to processors usually bring the lowest market price, but large volumes and specific, short harvest times somewhat offset this price difference. Selling processed fish is a value-added strategy that can increase market options and market price, but also increases labor and regulatory requirements.

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Financial Planning

The bank may require a formal written business plan if you seek financing. Such a plan is a very wise procedure to follow under any circumstance. A business plan can help account for the variables that will determine the success of your aquaculture enterprise before you have put a lot of money into it. A well-executed business plan will also serve as a valuable management tool during the operation of the aquaculture enterprise.

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Further Resources

Many electronic resources are available to beginning aquaculturists. An excellent starting location is the Aquaculture Network Information Center (AquaNIC) Home Page at http://ag.ansc.purdue.edu/aquanic/
A search engine such as Yahoo can be used to locate other lists on the World Wide Web.

Reference books and textbooks are useful sources of general and technical information on various aspects of aquaculture. Many of these are available at public and university libraries or through interlibrary loan. Additional sources of books on aquaculture are available from local bookstores and some aquaculture book suppliers (see list of book dealers in Appendixes).

Aquaculture periodicals, journals, newsletters, and magazines are good sources on all aspects of up-to-date research and recent developments covering various topics of aquaculture.

An excellent magazine is the bimonthly Aquaculture Magazine, dealing with all aspects of aquaculture. Their Annual Buyers Guide and Industry Directory are excellent reference issues and provide information for all people interested in aquaculture from the expert to the novice. An annual subscription to Aquaculture Magazine, which includes the Annual Buyers Guide and Industry Directory, is $19.00 and is available from:

Aquaculture Magazine
Subscription Department
PO Box 2329
Asheville, NC 28802
(704) 254-7334; Fax (704) 253-0677
http://www.aquaculturemag.com

Many federal and state agencies such as the Cooperative Extension Service, Fish and Wildlife Department, Department of Agriculture, and Natural Resources Conservation Service (NRCS), provide technical and diagnostic services, as well as publish information on specific aquaculture topics. Specific contacts in state or local offices of these agencies can be located in the enclosed Aquaculture Magazine Annual Buyer's Guide listing.

The National Sea Grant Program is a partnership between universities and the National Oceanic and Atmospheric Administration (NOAA) that started in 1966. Today, the 29 Sea Grant University programs produce and share research information on problems and new uses for the world's marine, Great Lakes and coastal resources. For more information on the Sea Grant Program, contact your state's Sea Grant Program listed in the Appendixes or visit their web-site at: http://www.mdsg.umd.edu/NSGO/

In the 1980's, the USDA established five regional Aquaculture Research and Development Centers. These centers are to develop research and extension education programs in aquaculture having either regional or national applications. These centers work in association with universities, colleges, state agencies, and private industry to address research priorities and technology transfer of new research findings. For more information about your Regional Aquaculture Center contact the nearest Regional Center listed in the Appendixes.

The Alternative Farming Systems Information Center (AFSIC) at the USDA National Agriculture Library (NAL) is another excellent source for aquaculture information. The AFSIC serves as a national clearinghouse for aquaculture information and provides materials to a variety of clientele, including farmers, government agencies, industry personnel, and prospective farmers. For more information about AFSIC contact:

AFSIC, NAL, ARS, USDA
10301 Baltimore Ave., Room 304
Beltsville, MD 20705-2351
(301) 504-6559; Fax (301) 504-6409
http://www.nal.usda.gov/afsic/

There is also many state, regional, national, and international professional and/or industry associations that deal with aquaculture development. Many of these associations have newsletters and other publications available. For information on membership, annual dues, and other services available, contact the associations directly. Many of these associations are listed on the electronic AquaNIC Home Page or in the Aquaculture Magazine Annual Buyer's Guide.

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Summary

There are many opportunities in the dynamic and expanding aquaculture industry. However, aquaculture has risks similar to those of any farming enterprise. The information provided here highlights many important factors to consider before proceeding with an aquaculture enterprise. Should you decide to proceed with an aquacultural enterprise, remember that technical resources, information, and expertise are critical to aquaculturists. The potential aquaculturists should get information about the specific cultural techniques and fish species they are interested in. They should also develop contacts with many associations and government agencies (such as fish disease labs) to get assistance if needed.

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U.S. Regional Aquaculture Centers

From Aquaculture Network Information Center (AquaNIC) Home Page, September 1998.

Center for Tropical and Subtropical Aquaculture
The Oceanic Institute
Makapu'u Point
Waimanalo, HI 96795-1820
(808) 259-7951; Fax (808) 259-8395
http://library.kcc.hawaii.edu/CTSA

North Central Regional Aquaculture Center
Natural Resources Bldg., Room 13
Michigan State University
East Lansing, MI 48824-1222
(517) 353-1962; Fax (517) 353-7181
http://ag.ansc.purdue.edu/aquanic/ncrac

Northeast Regional Aquaculture Center
University of Massachusetts Dartmouth
285 Old Westport Road
Research (Violette) Building, Room 201
N. Dartmouth, MA 02747-2300
(508) 999-8157; Fax (508) 999-8590
http://www.umass.edu/specialprograms/nrac

Southern Regional Aquaculture Center
Delta Branch Experiment Station
PO Box 197
Stoneville, MS 38776-0197
(601) 686-9311; Fax (601) 686-9744
http://www.msstate.edu/dept/srac/

Western Regional Aquaculture Center
Admin. Center, University of Washington
School of Fisheries
Box 357980
Seattle, WA 98195-7980
(206) 543-4290; Fax (206) 685-4674
http://www.fish.washing.edu/sofunits/wrac

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Sea Grants Programs & Directors

Alaska Sea Grant College Program
Ronald K. Dearborn
University of Alaska Fairbanks
P.O. Box 755040
Fairbanks, AK 99775-5040
(907) 474-7086
(907) 474-6285 FAX

California Sea Grant College System
James J. Sullivan
University of California
9500 Gilman Drive
La Jolla, CA 92093-0232
(619) 534-4440
(619) 534-2231 FAX

University of Southern California Sea Grant Program
Douglas J. Sherman
University of Southern California
USC Sea Grant Program
University Park
Los Angeles, CA 90089-0373
(213) 740-1961
(213) 740-5936 FAX

University of Connecticut Sea Grant Program
Edward C. Monahan

1084 Shennecossett Road
Groton, CT 06340-6097
(860) 405-9110
(806) 405-9109 FAX

University of Delaware Sea Grant Program
Carolyn A. Thoroughgood
Newark, DE 19716-3501
(302) 831-2841
(302) 831-4389 FAX

Florida Sea Grant Program
James C. Cato
University of Florida
Box 110400
Gainesville, FL 32611-0400
(352) 392-5870
(352) 392-5113 FAX

Georgia Sea Grant College Program
Mac V. Rawson
University of Georgia
Marine Sciences Building, Room 220
Athens, GA 30602-3636
(706) 542-5954
(706) 542-3652 FAX

Hawaii Sea Grant College Program
Charles E. Helsley
University of Hawaii
2525 Correa Road, HIG 238
Honolulu, HI 96822
(808) 956-7031
(808) 956-3014 FAX

Illinois-Indiana Sea Grant College Program
Phillip E. Pope
Purdue University, Department of Forestry and Natural Resources
1159 Forestry Building
West Lafayette, IN 47907-1159
(765) 494-3573
(756) 494-2422 FAX

Louisiana Sea Grant College Program
Jack R. Van Lopik
128 Wetland Resources Building
Louisiana State University
Baton Rouge, LA 70803-7507

(225) 388-6710
(225) 388-6331 FAX

Maine-New Hampshire Sea Grant College Program
Ann C. Bucklin
Kingman Farm
Durham, NH 03824-3512
(603) 862-0122
(603) 862-0243 FAX

Maine-New Hampshire Sea Grant College Program
Ian Davison, Interim Director
5715 Coburn Hall
University of Maine
Orono, ME 04469-5715
(207) 581-1435
(207) 581-1426 FAX

Maryland Sea Grant College Program
Christopher F. D'Elia
University of Maryland
0112 Skinner Hall
College Park, MD 20742-7640
(301) 405-6371
(301) 314-9581 FAX

MIT Sea Grant College Program
Chrys Chryssostomidis
E38-330/Kendall Square
292 Main Street
Cambridge, MA 02139-9910
(617) 253-7131
(617) 258-5730 FAX

WHOI Sea Grant Program
Judith E. McDowell
Woods Hole Oceanographic Institution
193 Oyster Pond Road, MS #2
Woods Hole, MA 02543-1525
(508) 289-2557
(508) 457-2172 FAX

Michigan Sea Grant College Program
Russell Moll
University of Michigan
2200 Bonisteel Boulevard
Ann Arbor, MI 48109-2099
(313) 763-1437
(313) 647-0768 FAX

Minnesota Sea Grant
Michael E. McDonald
University of Minnesota, Duluth
2305 E. 5th Street
Duluth, MN 55812-1445
(218) 726-8710, 6306
(218) 726-6556

Mississippi-Alabama Sea Grant Consortium
Barry A. Costa-Pierce
703 East Beach Drive
P.O. Box 7000
Ocean Springs, MS 39566-7000
(228) 875-9341
(228) 875-0528 FAX

New Jersey Marine Sciences Consortium
Michael P. Weinstein
Building #22
Fort Hancock, NJ 07732
(732) 872-1300 ext. 21
(732) 872-9573 FAX

New York Sea Grant
Jack S. Mattice
121 Discovery Hall
SUNY at Stony Brook
Stony Brook, NY 11794-5001
(516) 632-6905
(516) 632-6917 FAX

North Carolina State University
Ronald Hodson, Interim Sea Grant Director
101E 1911 Building
Box 8605
Raleigh, NC 27695-8605
(919) 515-2454
(919) 515-7095 FAX

Ohio Sea Grant College Program
Jeffrey M. Reutter
The Ohio State University
1314 Kinnear Road, Room 1541
Columbus, OH 43212-1194
(614) 292-8949
(614) 292-4364 FAX

Oregon Sea Grant Program

Robert Malouf
500 Kerr Administration Building
Oregon State University
Corvallis, OR 97331-2131
(541) 737-2714
(541) 737-2392 FAX

Puerto Rico Sea Grant College Program
Manuel Valdes Pizzini
University of Puerto Rico
P.O. Box 9011
Mayaquez, PR 00681-9011
(787) 832-3585
(787) 265-2880 FAX

Rhode Island Sea Grant Program
Scott W. Nixon
University of Rhode Island
Graduate School of Oceanography
South Ferry Road
Narragansett, RI 02882-1197
(401) 874-6800
(401) 789-8340 FAX

South Carolina Sea Grant Consortium
M. Richard DeVoe
287 Meeting St.
Charleston, SC 29401
(803) 727-2078
(803) 727-2080 FAX

Texas Sea Grant Program
Robert R. Stickney
Texas A & M University
1716 Briarcrest, Suite 702
Bryan, TX 77802
(409) 845-3854
(409) 845-7525

Virginia Sea Grant College Program
William L. Rickards
Madison House - 170 Rugby Road
University of Virginia
Charlottesville, VA 22903
(804) 924-5965
(804) 982-3694 FAX

Washington Sea Grant Program
Louie S. Echols

3716 Brooklyn Avenue N.E.
Seattle, WA 98105-6716
(206) 543-6600
(206) 685-0380 FAX

University of Wisconsin Sea Grant Program
Anders W. Andren
1800 University Avenue
Madison, WI 53705-4094
(608) 262-0905
(608) 263-2063 FAX

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Aquaculture Book Dealers

Alternative Aquaculture
PO Box 109
Breinigsville, PA 18031
(610) 395-7244

Aquaculture Supply
Division of Florida Aqua Farms
33418 Old St. Joe Road
Dade City, FL 33525
(352) 567-8540; Fax: (352) 567-3742

Aquatic Eco-Systems, Inc.
1767 Benbow Court
Apopka, FL 32703
(407) 886-3939 or (800) 422-3939
Fax: (407) 886-6787

Argent Chemical Laboratories
8702 152nd Avenue NE
Redmond, WA 98052
(800) 426-6258 or (206) 885-3777
Fax: (206) 885-2112

Atlas Publications
PO Box 265
Murphy, NC 28906
(704) 494-3011

AVA Publishing Company Inc.
PO Box 84060
Baton Rouge, LA 70884-4060

(504) 763-9656; Fax: (504) 766-0728
Web-site: www.brguide.com/AVA

Fresh-Culture Systems, Inc.
630 Independent Road
Breinigsville, PA 18031
(610) 395-7244; Fax: (610) 395-8202

Life Support Life Line
1841 N. Gaffey St. #F
San Pedro, CA 90731
Fax: (900) 288-CURE

Miami Aquaculture, Inc.
4606 SW 74 Avenue
Miami, FL 33155
(305) 262-6605; Fax: (305) 262-6701
Web-site: www.miami-aquaculture.com

Nautilus Publishing, Inc.
1200 Westlake Avenue N #801
Seattle, WA 98109
(206) 283-9532; Fax: (206) 284-2601
Web-site: www.nautiluspub.com

Old World Exotic Fish
Box 970583
Miami, FL 33197
(305) 248-6640; Fax: (305) 245-4228

Seacoast Information Services Inc.
135 Auburn Drive
Charlestown, RI 02813
(401) 364-9916; Fax: (401) 364-9757
Web-site: www.aquanet.com

Waiehu Fish Farm
1001 Malaihi Road
Wailuku, HI 96793
(808) 249-0959; Fax: (808) 242-8549

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Names of Common Aquaculture Species

Common	Scientific	Common	Scientific
Abalone	*Haliotis rufescens*	Killifish	*Fundulus spp.*

American allligator	*Alligator mississippiensis*	Koi	*Cyprinus carpio*
American bullfrog	*Rana catesbeiana*		
American eel	*Anguilla rostrata*	Largemouth bass	*Micropterus salmoides*
American lobster	*Homarus americanus*		
American oyster	*Crassostrea virginica*	Muskellunge	*Esox masquinongy*
Artic char	*Salvelinus alpinus*		
Alantic salmon	*Salmo salar*	Paddlefish	*Polyodon spathula*
		Pearl oyster	*Pinctada martensii*
Bigmouth buffalo	*Ictiobus cyprinellus*	Pike	*Esox lucius*
Black buffalo	*Ictiobus niger*	Pink salmon	*Oncorhynchus gorbuscha*
Black crappie	*Pomoxis nigromaculatus*	Pompano	*Trachinotus carolinus*
Bloodworm	*Glycera dibranchiata*	Pumpkinseed	*Lepomis gibbosus*
Blue crab	*Callinectes sapidus*		
Bluegill	*Lepomis macrochirus*	Rainbow trout	*Oncorhynchus mykiss*
Bowfin	*Amia calva*	Red drum	*Sciaenops ocellatus*
Brine shrimp	*Artemia salina*	Red swamp crawfish	*Procambarus clarkii*
Brook trout	*Salvelinus fontinalis*		
Bull minnow	*Fundulus grandis*	Shiner	*Notropis spp*
		Smallmouth bass	*Micropterus dolomieu*
Carp	*Cyprinus carpio*	Spiny lobster	*Panulirus argus*
Channel catfish	*Ictalurus punctatus*	Steelhead	*Oncorhynchus mykiss*
Chinook salmon	*Oncorhynchus tshawytscha*	Stone roller	*Campostoma spp*
Chub sucker	*Erimyzon spp.*	Striped bass	*Morone saxatilis*
Coho salmon	*Oncorhynchus kisutch*		
		Threadfin shad	*Dorosoma petenense*
Dungeness crab	*Cancer magister*	Tilapia	*Tilapia mossambica*
		Top minnow	*Poecilia spp.*
European eel	*Anguilla anguilla*	Tubifex worm	*Tubifex tubifex*
European lobster	*Homarus grammarus*		
		Walleye	*Stizostedion vitreum*

Flathead minnow	*Pimephales promelas*	White bass	*Morone chrysops*
		White crappie	*Pomoxis annularis*
Giant river prawn	*Macrobrachium rosenbergii*	White river crawfish	*Procambarus blandingii*
Golden shiner	*Notemigonus crysoleucas*	White sturgeon	*Acipenser transmontanus*
Goldfish	*Carassius auratus*		
Grass shrimp	*Palaemonetes spp.*	Yellow perch	*Perca flavescens*
Green sunfish	*Lepomis cyanellus*		

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Prepared by Lance Gegner
ATTRA Technical Specialist
October 1998

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MARKETING ILLINOIS AQUACULTURE PRODUCTS

Dan Selock
Office of Economic and Regional Development, SIUC
January, 1999

Marketing is providing the right product (positioning and quality) at the right time, in the right place (target markets), at the right price (competitive), and with promotion (image). It must be customer oriented and not production oriented. Marketing is concerned with those **activities which anticipate consumers' needs** and direct the flow of goods and services from producers to consumers. This occurs to satisfy the needs of consumers and accomplish either the economy's (the macro view) or the firm's (the micro view) objectives.

Marketing is doing the work needed to answer the questions **who, where, when, what, and how.** It takes time, effort, planning, and creativity. Sometimes it's hard work, other times it's fun.

The "marketing concept" says that *a firm should focus all its efforts on satisfying its customers, at a profit.* That means produce and sell what the customer wants instead of what is easiest or most convenient for you to produce. Give the customer what THEY WANT (marketing-oriented), INSTEAD OF WHAT YOU WANT (production-oriented).

The four P's of marketing are:

1. PRODUCT – live eggs, fry, fingerlings, and mature fish; processed fish in-the-round, whole-dressed, fillets, steaks, strips, fresh, frozen, smoked, value-added, etc.
2. PLACE – target market = market segment is a homogeneous group; natural market = people you know; local market = within a 50 mile radius; farmers' market in most cities; extended market
    a. Live sales to custom processors, pay lakes, live haulers, pond and lake owners, the IL Department of Natural Resources (IDNR),

at farmers' markets (need "Retail Fish Dealer's" license @ $10/yr.), to feed and seed dealers (fish day)

b. Processed fish sales to local grocery stores, restaurants, fish markets, taverns, institutions – schools, hospitals, nursing homes, senior citizen centers, and retirement homes, local clubs and organizations – the Kiwanis, Elks, Moose Lodge, Masons, Lions, Shriners, Knights of Columbus, Fire Department, Boy Scouts, AA, and churches (seasonal fish fry), local businesses – car dealerships, banks, lumber yards, and sports equipment suppliers, and individuals

3. PRICE – channel catfish = $1.25/# live, $2.50 whole-dressed, $4.50 fillets (retail); tilapia = $1.90/# live; hybrid striped bass = $2.75/# live; big head carp = $0.85/# live; freshwater shrimp = $7.50/# live

* You do not legally own and cannot legally sell the fish you raise, regardless of how much money you may spend to buy, feed, and culture them, until you have acquired an Illinois "Aquaculture Facility Permit." Without the permit, all fish in the State of Illinois belong to the State of Illinois. With the permit, your fish are designated as livestock instead of sports fish, therefore you can legally own and sell them. According to the IDNR, anyone who plans to engage in the breeding, hatching, propagation, or raising of aquatic life, whether on the Approved List or not, needs this permit. It may take from one week to a month, or longer if a species <u>not</u> on the Approved List is involved. A fee of $50 per year is required, and it is renewable 1 February each year. Call the Aquaculture Coordinator, Jake Wolf Memorial Fish Hatchery, Manito, IL, 309/968-7531.

4. PROMOTION – fresh vs. frozen, grain fed, farm raised, and "Illinois Product" label (official IL Dept. of Ag. logo)

QUALITY	PRICE	SERVICE

You can ONLY DO TWO of the three WELL. One must be sacrificed in order to do the other two as well as possible.

Products are different in only two ways:

1. DIFFERENTIATED VALUE – high quality, good service, something new or different, fresh, safe, clean, wholesome, healthy, low calorie, polyunsaturated, etc.
2. PRICE – competitive, on sale, a bargain, etc.

Buyers are looking for a quality product with consistent and uniform characteristics that has been properly handled. There must also be an adequate volume of the product throughout the year or season. Buyers like to be notified of the availability of a product in advance. And they look for dependable performance in filling orders.

A few ideas for individualized marketing are:

1. Always sell a good product
2. Begin a mailing list and use it to notify about your peak season
3. Offer a known product
4. Entice the lazy purchaser by offering customization = value-added products
5. Entice the bargain hunters with "good deals"
6. Establish and display the days and times during which sales will be made and don't alter the hours for anyone unless you realize that you will then be obligated to do so for everyone
7. Be patient with customers – "The customer is always right"
8. Don't over-spend on advertising

Marketing aquaculture products is no different than marketing other agriculture products. Marketing is as important as production, financing, cash flow, and other profit determining factors. <u>Before beginning production</u> or selecting a specific marketing alternative, some <u>general marketing principles should be considered and a marketing strategy developed.</u>

A Marketing Strategy involves three elements:

1. Determining the present situation
2. Determining final marketing goals/objectives:
   a. Must be specific
   b. " " obtainable

c. Must be measurable
d. "   " on a time line
3. Developing a logical plan for getting from present to final goals

Determining the present situation often involves the most work and time:

1. Assess the marketplace
    a. Supply and demand
    b. Market trends
2. Personal financial circumstances
    a. Levels of risk
    b. Ability to carry debt
3. Available marketing alternatives
    a. Use enterprise budgets
    b. Time lines
    c. Cash flow
    d. Compatible with other personal or business goals

Determining final marketing goals is important so one does not "drift aimlessly" through sales opportunities.

1. Relate goals to operating costs
2. Know how much different levels of operation will cost and establish goals that will at least cover costs
3. The level that goals exceed operating costs will depend on the willingness to accept risks and other personal and business goals

Consider all reasonable marketing alternatives and develop a marketing plan. Evaluate each alternative in terms of labor and financial requirements, as well as, advantages and disadvantages. The selection of a specific combination of marketing alternatives should be tailored to the market assessments, individual financial circumstances, and the size of the operation.

After a marketing strategy has been developed, write it down, hypothetically test it, and modify as needed. Think of all things that could happen. <u>Once a final strategy has been selected, follow it.</u>

A Basic Overview of Aquaculture

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Summary

Aquaculture is a form of agriculture which involves the propagation, cultivation, and marketing of aquatic plants and animals in a more-or-less controlled environment. World fish farming started as early as 2000 B.C., but United States aquaculture started in the late 19th century. The firmly established catfish industry started in the early 1960s and has gone through four phases. The current phase shows a slowing in the expansion of catfish farming, and an increase in the production of other species.

Water supply and quality are the most important factors in selecting the proper location for an aquaculture facility. Wells and springs are the best sources of water, but other sources are acceptable if the quality and quantity are adequate. Important water quality characteristics to consider are temperature, dissolved oxygen, ammonia, nitrites, nitrates, pH, alkalinity, and hardness. In respect to temperature, fish may be classified as warmwater, coolwater, and coldwater species, with each type having an optimal temperature range.

Of the six types of aquaculture, the production of food organisms such as catfish, trout, and hybrid striped bass are the best known. Others include: bait, aquaria, fee-fishing, lake stockings, and biological supply houses. Organisms from each of these six types will be produced using one of the following methods: ponds, cages, raceways, or water-recirculating systems.

Before considering aquaculture as a business, much research on requirements should be done. This research should include marketing, stocking, feeding, harvesting, transport, and capital investments.

Introduction

Are you considering aquaculture as a new business or as a way of diversifying your existing business? If the answer to this question is yes, then you should ask yourself, "How much do I really know about aquaculture?"

There are many levels of knowledge of aquaculture - from the person who has many years experience in running a successful aquaculture operation, to the beginner who has an interest in, but really no knowledge of, what aquaculture is or involves. This publication is directed to those who have an interest in aquaculture, but who lack knowledge about it or experience in the business. The reader should note that this publication is not intended to be a complete introduction to aquaculture. It does not cover many important topics such as stocking, feeding, harvesting, transport, marketing, and others. In addition, the topics that are covered are not complete. Instead, the intention here is only to introduce some aspects of aquaculture.

History

World fish farming was first practiced as long ago as 2000 B.C., in China. The Bible refers to fish ponds and sluices (Isaiah, Chapter 19, verse 10~, and ornamental fish ponds appear in paintings from ancient Egypt. European aquaculture began sometime in the Middle Ages and transformed the "art" of Asian aquaculture into a science that studied spawning, pathology, and food webs. One of the most significant developments was the invention of culture methods for trout, which were being introduced into natural waters by the mid-1800s.

Aquaculture is a form of agriculture that involves the propagation, cultivation, and marketing of aquatic animals and plants in a controlled environment. The history of aquaculture in the United States can be traced back to the mid to late 19th century when pioneers began to supply brood fish, fingerlings, and lessons in fish husbandry to would-be aquaculturists. Until the early 1960s, commercial fish culture in the United States was mainly restricted to rainbow trout, bait fish, and a few warmwater species, such as the buffaloes, bass, and crappies. Many of these early attempts at fish husbandry failed because: (1) operators were not experienced in fish culture, (2) ponds were not properly built, (3) low-value species were being raised, and (4) selected species lacked adequate technical support.

The now firmly established catfish industry, which originated in the south eastern United States, started in the late 1950s. Since then this industry has gone through four identifiable phases. The first, or pioneering phase (19601970), was characterised by rapid expansion and relatively high production costs that resulted in low yields and inefficiency. The second phase (1971-1976) gave rise to major improvements in production and lower unit costs. Average annual yields increased from 1,500-2,000 pounds per acre (Lb/acre) to 3,000 - 4,000 lb/acre. There was, however, a drastic shakeout of unprofitable and marginal producers when feed costs rose as a result of a scarcity of fish meal. The third phase (1977-1982) saw vastly improved productivity, greatly increased acreage, and lower production costs. The major sales outlet became the wholesale processing plant. The fourth phase (19821989) saw a decreased rate of expansion in the catfish industry, while production of other aquaculture products such as salmon, striped bass, crawfish, and tilapia increased.

The growth of the catfish industry through the four phases mentioned has resulted in an increase in the industry's size from about 400 acres in 1960 to more than 161,000 acres and 410 million pounds processed in 1991. Economically, this production had a farm gate value of more than $264 million. Mississippi dominates the industry with 59 percent of the acreage and 75 percent of the production. Today, the catfish industry's growth rate has slowed somewhat, but the potential for increased demands for catfish and other aquaculture products is very favourable.

There have been significant increases in demand for fish and seafood in the United States and throughout the world. Per capita consumption in the United States rose from 12.5 pounds in 1980 to 15.5 pounds in 1990, an increase of 19 percent. With the increased health consciousness in the United States, per capita consumption of aquaculture products will continue to increase. In addition, the supply of "wild" caught fish from conventional capture sources has declined because of over-exploitation, pollution, and habitat destruction. These conditions will mean an ever-increasing demand for aquaculture products.

To fulfil the increased demand more people will enter the existing aquaculture industry, either at the production level or in a support position. Before doing so, the potential aquaculturist must understand more about aquaculture and what it involves. As stated, aquaculture is a form of agriculture, and many of the same management strategies are used. As in any agricultural enterprise, the aquacultural farmer tries to maximise yields (profits) while minimising inputs (costs and labour). However, there are reasons why aquaculture can be more productive and profitable than land-based agriculture.

Meaningful comparisons of productivity are complicated, but fish have certain advantages over land animals in their suitability for farming. Being cold-blooded, fish do not have to expend energy in maintaining body temperature. Also, unlike land animals, they do not have to support their weight and should therefore be inherently more efficient at converting food into flesh. Because a fish farm uses a three-dimensional rearing area, fish have the added dimension of depth in which to grow, thus increasing yields on a per acre basis. Production in ponds can approach 10,000 pounds per acre annually compared to approximately 1,000 pounds per acre annually for beef cattle. In general, fish have a lower proportion of inedible bones and offal, which means a greater processed weight for the producer.If there are so many advantages to aquaculture over land-based agriculture, why are more people not involved? There is no single answer to this question. Instead, one must first realise that aquaculture is still several decades behind traditional livestock husbandry in research and development. Virtually every aspect of aquaculture can still be improved. The lack of available information, the need for training in the husbandry of aquatic organisms, and the lack of suitable markets are three obstacles that impede the development of the aquaculture industry in the North Central Region.

In the following sections some of the basic concepts for the husbandry of aquatic organisms, specifically fish, will be discussed.

Water sources

Water supply is the most important factor in selecting the proper location for an aquaculture facility. Aquatic organisms depend upon water for all their needs. Fish need water in which to breathe, eat, grow, and reproduce. Large quantities of water must be available year-round. If water is not available all the time, but there is some way to store it, then that site still may be suitable. The key, of course, is that water must always be available and in good supply.

Water sources can be classified as: wells, springs, groundwater, streams, rivers, lakes, and municipal. Of these seven possible sources, wells and springs rank the highest in terms of overall quality. Wells and springs are usually uncontaminated and have no unwanted fish or fish eggs. The only drawbacks to well and spring water are their low concentrations of dissolved oxygen (which fish need to breathe), and their high concentrations of dissolved gases such as carbon dioxide, and metals such as iron. These problems can be overcome. An example of a specialised use of well water is the warm water from geothermal wells being used to grow tropical food fish in such non-tropical areas as Idaho.

Groundwater sometimes is used where ponds are dug into the existing water table. This type of pond is generally less productive than ponds filled from other sources because of the low productivity of the surrounding soil. Streams, rivers, and lakes also can be used to produce aquatic organisms, but they are subject to any contaminants that could wash in from the surrounding watershed. In addition, unwanted fish or fish eggs must be filtered from these existing water bodies.

Water quality

To a great extent water quality determines the success or failure of a fish farming operation. Physical and chemical characteristics such as suspended solids, temperature, dissolved gases, pH, mineral content, and the potential danger of toxic metals must be considered in the selection of a suitable water source. Of these many water quality characteristics, only temperature, dissolved oxygen, ammonia, pH, and alkalinity will be discussed. In existing systems, a close watch should be kept on these critical characteristics.

Temperature

As mentioned, fish are cold-blooded organisms and assume approximately the same temperature as their surroundings. Metabolic rates increase rapidly as temperatures go up. Many biological activities such as spawning and egg hatching are geared to annual temperature changes in the natural environment. These temperatures vary according to the particular species. Fish are generally categorised into warmwater, coolwater, and coldwater based on optimal growth temperatures. Channel catfish are an example of a warmwater species, with a temperature range for growth between 70° and 85°F. A temperature of 82°F is generally considered optimum for growth. This explains, in part, why catfish farming in the southern states, with their longer growing season, has been so successful.

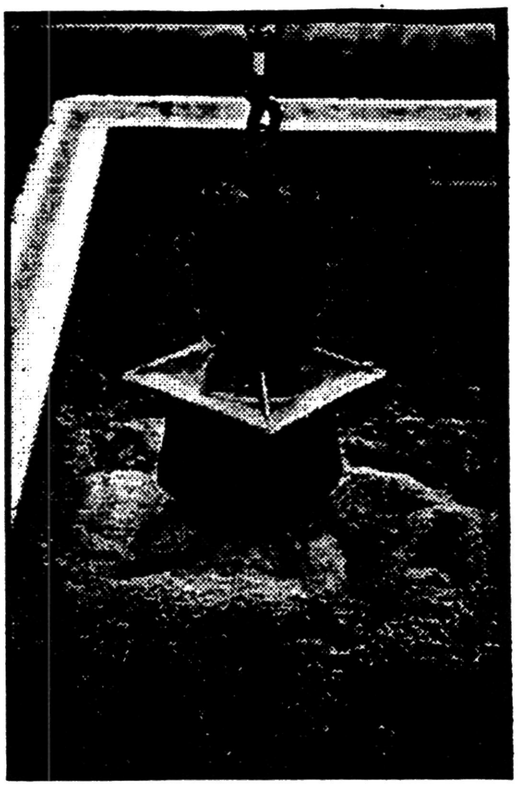
Striped bass, hybrid striped bass, walleye, and yellow perch are examples of coolwater species. Ranges for optimum growth fall between 55° and 75°F. Temperatures in the upper end of this range are generally considered best for maximum growth for all coolwater species.

Coldwater species include all species of salmon and trout. Two of the more commonly cultured coldwater species in the North Central Region are rainbow trout, and to a lesser extent, brown trout. Their optimal temperature range for growth is 48°- 60°F.

Ideally, species selection should be based partly on temperatures of the water supply. Any attempt to match the fish with improper water temperatures will involve energy expenditures for heating or cooling to within the desired range. This added expense will subsequently reduce the farmer's profits.

Dissolved oxygen

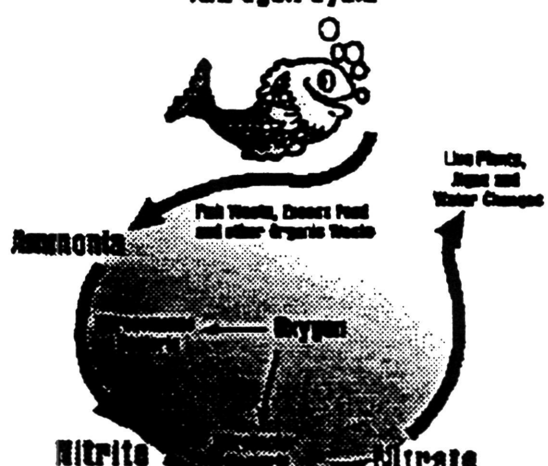
Like humans, fish require oxygen for respiration. Dissolved oxygen (DO) concentrations are expressed in parts per million (ppm) or milligrams per litre (mg/l). Both methods are the same since 1 mg/l is equal to 1 ppm. Some fish such as tilapia and carp are better adapted to withstand periodic low DO concentrations. However, concentrations greater than 4 to 5 ppm are required for good growth in fish. The oxygen that fish need to breathe also is consumed by the breakdown of fish wastes and uneaten feed.



Oxygen enters the water in three ways: (1) through air diffusing into the water at the surface, (2) through the photosynthesis of microscopic plants (algae) in ponds. (In this process carbon dioxide is converted into food by plants and oxygen is released as a by-product.) (3) through mechanical means. (The levels of oxygen can be increased.)

Ammonia, nitrites, and nitrates

Fish excrete ammonia and a lesser amount of urea into the water as wastes. Two forms of ammonia occur in aquaculture systems: ionised and un-ionised. The un-ionised form of ammonia is extremely toxic to fish; ionised ammonia is not. Both forms are grouped together as "total ammonia nitrogen." Through biological processes, toxic ammonia can be degraded to harmless nitrates.



Reproduced from That Fish Place catalogue

In natural waters, such as lakes, ammonia may never reach critically high levels due to the low densities of fish. But the aquaculturist must maintain high densities of fish and therefore runs the risk of ammonia toxicity. Un-ionised ammonia levels rise as temperature and pH increase. Toxicity levels for un-ionised ammonia depend on individual species; however, levels below 0.02 ppm are generally considered safe. Dangerously high ammonia concentrations usually are limited to water reuse systems, where water is continually recycled. However, the intermediate form of ammonia - nitrite - has been known to occur at toxic levels in fish ponds.

pH, alkalinity, and hardness

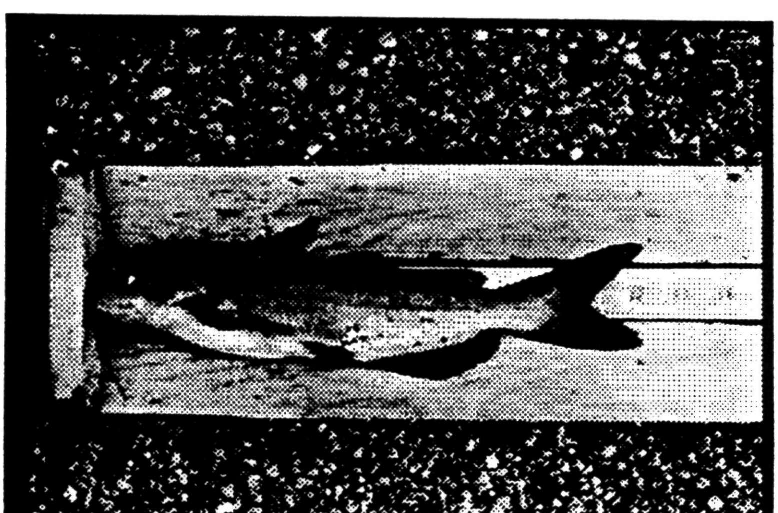
The quantity of hydrogen ions in water determines whether it is acidic or basic. The scale for measuring the degree of acidity is called the pH scale, which ranges from 1 to 14. A value of 7 is neutral, neither acidic nor basic; values below 7 are considered acidic; above 7 basic. The acceptable pH range for fish culture is normally between pH 6.5 and 9.0.

Alkalinity is a system by which wide pH fluctuations are prevented or "buffered." It is a measure of the carbonates (CO3-2) and bicarbonates (HCO3) as expressed in terms of equivalent calcium carbonate (CaCO3). An example of this type of buffering system is the addition of agricultural lime to prevent decline in pH. Hardness is the measure of the calcium and magnesium portion of the buffering system. These two elements can be absorbed by the fish's gills and, in addition to other uses, they help with the bone development in fish. Fish will grow over wide ranges of alkalinity and hardness, but values of 12(}400 ppm are considered optimum.

Types of aquaculture

The most widely recognised types of aquaculture in the United States is the catfish industry in the south and the trout farms in Michigan and the West. Both of these industries involve the culture of a single fish species for food. Another familiar type is the production of bait minnows and crayfish for use by recreational fishermen. There are several categories for production of aquaculture products: (1) food organisms, (2) bait industry, (3) aquaria trade-ornamental and feeder fish, (4) fee fishing, (5) pond and lake stockings, and (6) biological supply houses.

Food organisms



Catfish

The production of food organisms is the most common form of aquaculture practiced in the United States. Of the approximately 60 species that have potential to be grown as food fish, technical support and markets limit these to a select few. The most common food fish and shellfish being grown in the United States are: catfish, trout, salmon, carp, crayfish, freshwater shrimp, striped bass and their hybrids, and tilapia.

Bait industry

Sometimes known as minnow and crayfish farming, the bait industry is a surprising one. Although the exact size of the industry is not known, nearly all states east of the Rocky Mountains, as well as Arizona and California west of the continental divide, have some bait farming. Species of fish and shellfish produced include: golden shiners, fathead minnows, goldfish, carpsuckers, bluntnose minnows, tilapia, suckers, and crayfish.

Aquaria trade

The ornamental fish, plant, and snail industry may be divided into two types. First, the tropical fish and plant industry, which originated In south Florida where annual temperatures are similar to those of the plant or animal's native range. The other varieties of ornamentals cultured are the goldfish and the Koi Carp, which are coolwater species. The tropical fish group does not tolerate temperatures associated with the temperate zone, and thus is unsuitable in the Midwest for pond production during most of the year.

There is potential to produce several species indoors in tanks or aquaria where temperatures can be closely controlled. Species that could he produced in this way are several of the livebearers (guppies, mollies, and swordtails), gouramis, and cichlids, such as angel fish and discus fish There is also a demand for native fish in the ornamental industry. Small garfish, sturgeon, and the bowfin are two examples of native fish that are being sold as ornamentals.

In addition to growing ornamental fish, there are farmers who grow fish for use as "feeders" for the larger fish-eating aquarium fish. Most feeder fish sold are goldfish, but other species sold when approximately 1-2 inches long can also be considered feeder fish.

Fee fishing

Fee fishing ponds, sometimes called catch-out ponds, usually are small, heavily stocked bodies of water containing one or more kinds of fish that are of catchable size. There are three basic types of fee fishing operations: long-term leasing, day leasing, and fish-out. Exclusive long-term fishing rights to a private pond or lake can be leased to a group or individual, e.g., a hunting club. Day leasing is similar to long-term leasing but it is for a single day. Generally, the operator of a fish-out pond charges a basic fee for one-half or one day of fishing, and/or a fee for each pound or inch of fish caught. Additional facilities provided at fish-out ponds may include snack bar, bait and tackle shop, boat rentals (for larger ponds), picnic facilities, public rest rooms, and parking facilities.

The type of fish stocked into fee fishing ponds depends on pond conditions. Coldwater ponds are normally stocked with trout. Warmwater ponds usually are stocked with channel catfish, bullheads, and/or hybrid sunfish. Ponds stocked with bass and bluegills usually do not supply the catch rate necessary for a successful fee fishing business unless they also are regularly stocked with catfish.

Pond and lake stockings

With the many farm ponds found throughout the North Central Region, production of sport fish to stock them can be a very profitable business. In addition to farm ponds, fish needed for stocking city or county lakes may be obtained from the private producer. Many combinations of fish are suitable for stocking in ponds and lakes. Some of the more commonly cultured species are largemouth bass, bluegill, redear sunfish, hybrid sunfish, channel catfish, bullheads, trouts, crappies, walleye, yellow perch, fathead minnows, bluntnose minnows, and golden shiners. Generally fish are stocked at below catchable size, and then grow more in the ponds.

Those who purchase fish for pond or lake stockings usually buy mixtures of several species and stock according to "recipes." This procedure allows the pond to maintain a balance of predator fish (largemouth bass, walleye, and trout) and prey species (bluegill and other sunfishes) for several years. However, a pond owner will usually need to renovate his or her pond and restock every five to seven years to maintain the proper ratio for predator and prey species. This periodic restocking provides good management for the pond owner and a continual market for the suppliers of stockable-size fish.

Biological supply houses

Raising aquaculture products for biological supply houses covers a broad range of organisms. Everything from algae to turtles is used in some form by educational and research institutions. The producer should conduct a good deal of marketing research before attempting to specialise in only one aspect of production for biological supply houses. Instead of specialising, some producers take advantage of aquatic organisms that live with the culture of their target species. They sell these to biological supply houses as a supplemental source of revenue .

Production phases

Regardless of the form of aquaculture undertaken, it will involve at least one of the following production phases: (1) securing and spawning of brood stock, (2) hatching of eggs, (3) growing fry to produce fingerlings, and (4) stocking and grow-out of fingerlings to marketable size.

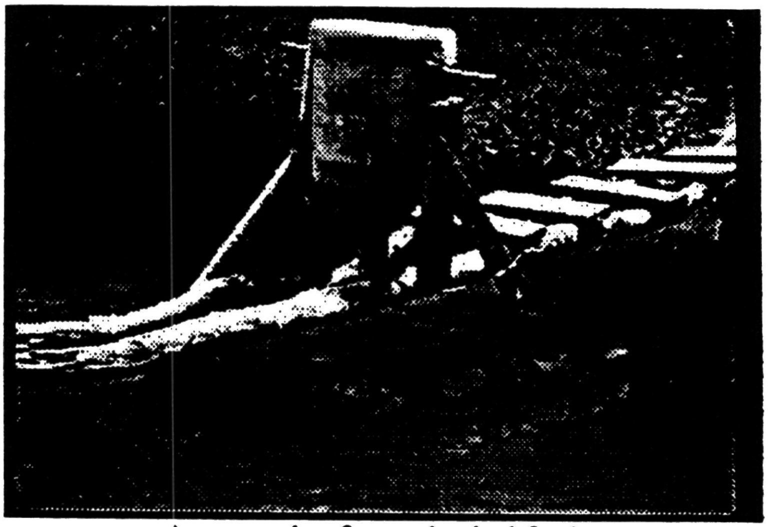
Some farmers will perform all phases of production while others may specialise and skip one or more of the four phases of production. These farmers may, for example, produce only fingerlings to sell to farmers who will in turn grow those fish for market as food fish. Most trout farmers in the eastern United States purchase eggs from large western farms, thus eliminating the need to maintain brood stock for spawning. The number of production levels chosen for an individual farm usually is based on: the size of theoperation, expertise, amount of capital available to purchase specialised equipment, and personal preference.

Marketing is extremely important in the production of any type of aquaculture species. Without a well-thought-out marketing plan, the aquaculturist may be faced with a serious obstacle. Before attempting to go into full scale production, the producer should have several market outlets for the product.

Production methods

When describing aquatic production systems, the aquaculturist refers to the water-holding facility in which the organisms are grown. Several kinds of water facilities may be needed for growing fish. The kind of facility depends on the size of the farm and the type of fish farming. These facilities are grouped into four types: ponds, cages, raceways, and recirculating systems.

Further distinctions can be made within each type of facility based on the level of intensity used by the producer. The terms "extensive" and "intensive" are sometimes used when describing the amount of inputs (labour, feed, materials, or equipment) used in an operation. Extensive production usually means the addition of no or few inputs with a resulting low production level. Natural lakes and farm ponds are examples of extensive systems. Fish culture ponds sometimes are described as being extensive even when some very intensive management strategies are used. Intensive production, on the other hand, refers to the increasing use of inputs, which generally increases the yield.

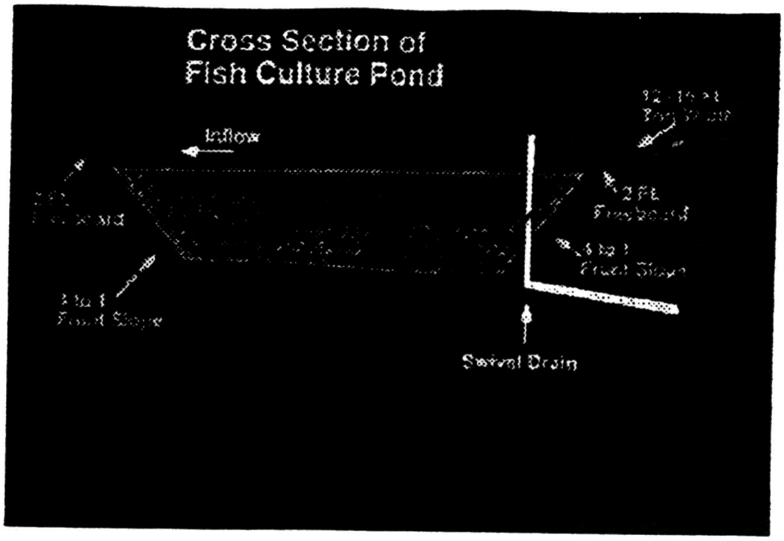


An example of a mechanical feeder

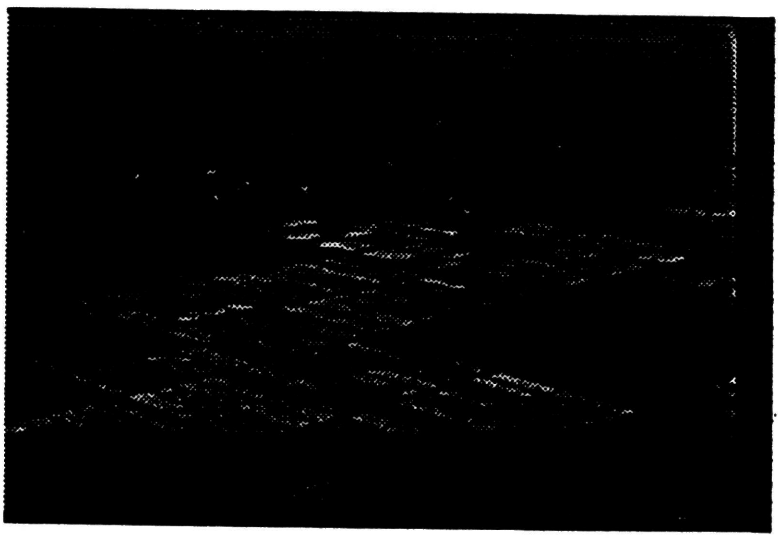
It should be noted that a point comes when the inputs exceed the outputs. This trend for outputs to increase more slowly than inputs is called the law of diminishing returns and usually is associated with expenses versus income.

Ponds

The most common production system in use is the earthen pond. These ponds may be anything from a small farm pond to one specifically designed and built for aquaculture. While the non-drainable farm pond or water storage lake can be used for many types of aquaculture, it is not well-suited for others due to the lack of a drainage system, questionable water quality, and inconsistent water depths. Nevertheless, non-drainable farm ponds are used to produce fish in cages and in fee-fishing operations.



Ponds constructed for fish culture are called dike or levee ponds. Levee ponds require an adequate amount of good quality water and clay soils that retain water. The slope of the pond site also affects the selection of the site. Ponds built on a slight slope can be easily gravity-drained. Anywhere from a 2 to 5 feet rise per 100 feet is usually an acceptable slope. The shape of levee ponds is usually rectangular, but occasionally, square ponds or contour ponds are used. An advantage of rectangular ponds is the reduced length of the seine needed to harvest the pond.

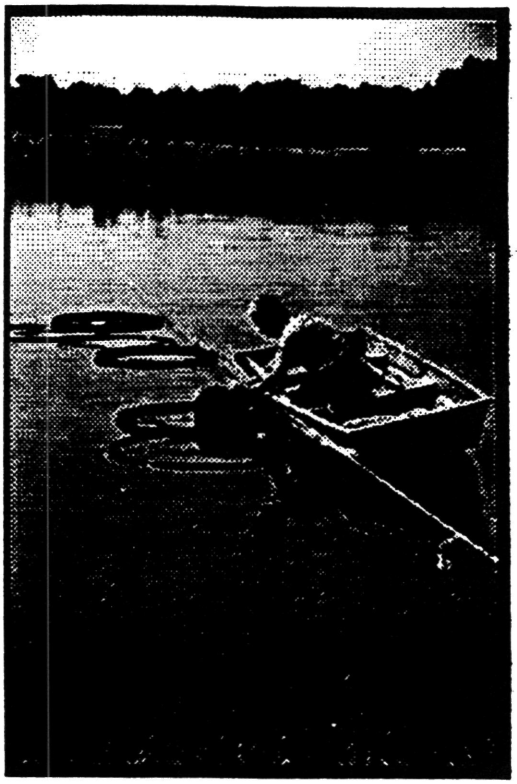


The types of levee ponds are holding ponds, spawning ponds, rearing ponds, and grow-out ponds. The size of a levee pond depends on its planned use. For example, a pond used for spawning fish will be smaller then a pond used to grow out fish to marketable size. Spawning ponds can be as small as one-fourth acre and grow-out ponds may exceed 20 acres. Smaller ponds are easier to manage, however, they are more expensive to build on a per unit area basis.

Production in ponds can range from 2,000 to 10,000 pounds per acre per year (lb/acre/yr.) depending on the level of intensity. One way to increase annual production is through continual harvesting. This is accomplished by selectively harvesting the larger fish and replacing them with new fingerlings. When using this method, a single yearly harvest is replaced by staggered harvests.

Caged Culture

Cage culture of fish uses existing water resources (i.e. lakes or ponds) but encloses the fish in a cage or basket, which allows water to pass freely between the fish and the pond or lake. One of the main advantages is the ease of harvesting. Cage culture is an alternative to pond culture where typical levee ponds are not available. Small lakes, mining pits, and farm ponds may be used in cage culture. Cage culture is attractive because ponds or lakes too deep for seining can still be used to produce fish.



Though the shape and size of an individual cage can vary, some of the more common cages are rectangular, 3x4x3 feet or 8x4x4 feet; square, 4x4x4 feet or 8x8x4 feet; and round, 4x4 feet. These cages float and are placed in the open part of the pond with at least two feet of water between the bottom of the cage and the pond bottom. A key point to recognise in cage culture is that total production is no greater in cages than in ponds, even though it appears that the farmer will only be using a small part of the water. In fact, good water circulation must be assured to prevent oxygen depletion in and around the cages.

Production rates in cages is similar to ponds, with 1,000 - 5,000 lb/acre/yr. possible from a series of cages. The production rate can be increased from the double cropping of a warmwater and a coldwater species. For example, catfish are grown in the warm summer months, then harvested and replaced by trout in the winter. Production of up to 500 lb/year is possible from a single 4x4x4 foot cage.

Raceways

Rectangular raceways are used almost exclusively for trout production, but it is possible to culture other species of fish in them. A raceway production facility requires large quantities of inexpensive high quality water. The water is normally obtained from a spring or stream and is passed through the raceways using gravity ("once-through" or "open" system). The raceways are arranged in a series on a slightly sloping terrain, taking advantage of gravity to move the water through each unit.

Raceways may be built of concrete, block, tile, bricks, wood, or other durable materials, or they can be earthen. Earthen raceways are cheaper to build, but the high volumes and velocity of water cause varying degrees of erosion. Thus, they are not often used. Dimensions of raceways vary, but generally a length:width:depth ratio of 30:3:1 provides favourable characteristics.

Recirculating raceway facilities also are possible. In this type of raceway, culture water is pumped back to a processing reservoir where wastes are removed. This type of facility is more expensive to operate and more complicated because of the energy needed to run the pump and the equipment needed to remove the waste.

Production in raceways is greater than that of ponds or cages because of the continual exchange of fresh water, which removes the wastes. Because production is partly based on flowing water through the raceways, yields are measured in pounds per gallon per minute (lb/gal/minute). Yields exceeding 20 lb/gal/minute have been obtained in intensive raceway production.

Water Recirculating Systems

A closed recirculating system refers to a production method that recirculates the water rather than passing it through only once. As a result, less water is needed for this type of system than for ponds or open raceways. Most recirculating systems are indoors, which allows the grower to maintain more control over the water (i.e. temperature) than in other production methods. Even though recirculating systems have many advantages over other production types, their overriding disadvantage is the initial capital investment.

Closed recirculating systems are generally composed of four components: the culture chambers, a primary settling chamber, a biological filter, and a final clarifier or secondary settling chamber. Each of these units is important to the system, although some closed recirculating water system designs have eliminated the secondary settling chambers. The components may be separate units or they may be arranged in combinations that make the system appear to have only one or two compartments. Each component may be very large or relatively small, but each must be in proper proportion to the others if the system is to perform properly. Production rates in closed recirculating systems vary considerably and usually depend on the type of system used and the user's expertise. Therefore, an accurate range of production could be very misleading. With this in mind, estimated yields range from 0.25 to 0.8 pounds per gallon (lb/gal). Producers interested in water recirculating systems should construct and test smallscale pilot systems before attempting large-scale production systems.

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Fact Sheet AS-503

WATER QUALITY

A Fish Farmer's Guide to Understanding Water Quality

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To help the fish farmer better understand the properties of water as they affect fish culture, the following subjects will be covered in this fact sheet:

- Physical Characteristics of Water
- Water Balance in Fish
- Sources of Water
- Water Quantity
- Water's Physical Factors
- Water's Chemical Factors

Introduction

Importance of Water Quality in Aquaculture

Fish perform all their bodily functions in water. Because fish are totally dependent upon water to breathe, feed, grow, excrete wastes, maintain a salt balance, and reproduce, understanding the physical and chemical qualities of water is critical to successful aquaculture. To a great extent, water determines the success or failure of an aquaculture operation.

Physical Characteristics of Water

Water can hold large amounts of heat with a relatively small change in temperature. This heat capacity has far reaching implications. It permits a body of water to act as a buffer against wide fluctuations in temperature. The larger the body of water, the slower the rate of temperature change. Furthermore, aquatic organisms take on the temperature of their environment and cannot tolerate rapid changes in temperature.

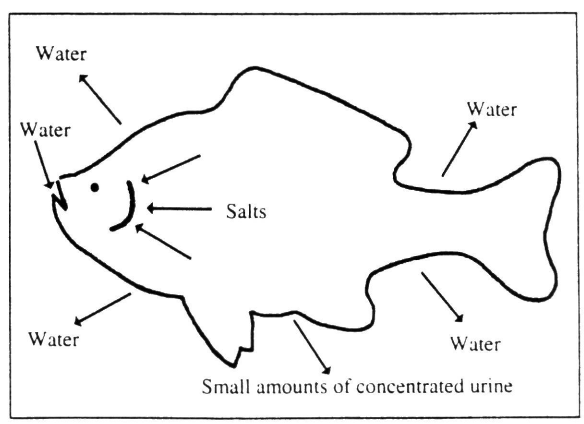
Water has very unique density qualities. Most liquids become denser as they become cooler. Water, however, gets denser as it cools until it reaches a temperature of approximately 39°F. As it cools below this point, it becomes lighter until it freezes (32°F). As ice develops,water increases in volume by 11 percent. The increase in volume allows ice to float rather than sink, a characteristic that prevents ponds from freezing solid.

Far from being a "universal solvent," as it is sometimes called, water can dissolve more substances than any other liquid. Over 50 percent of the known chemical elements have been found in natural waters, and it is probable that traces of most others can be found in lakes, streams, estuaries, or oceans.

Water Balance in Fish

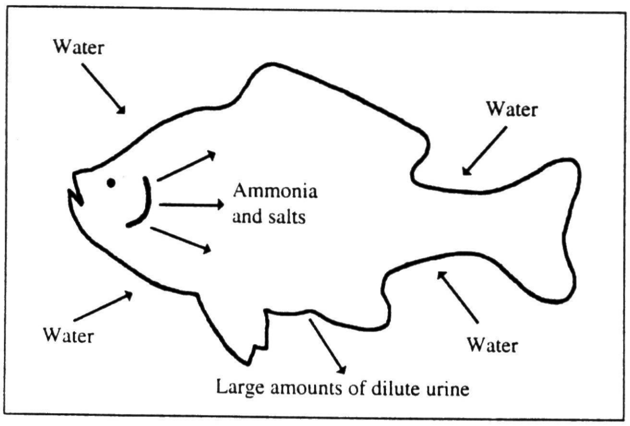
The elimination of most nitrogen waste products in land animals is performed through the kidneys. In contrast, fish rely heavily on their gills for this function, excreting primarily ammonia. A fish's gills are permeable to water and salts. In the ocean, the salinity of water is more concentrated than that of the fish's body fluids. In this environment water is drawn out, but salts tend to diffuse inward. Hence, marine fishes drink large amounts of sea water and excrete small amounts of highly salt-concentrated urine (Figure 1).

Figure 1. Direction of water, ammonia, and salt movements into and out of saltwater fish. Saltwater fish drink large amounts of water and excrete small amounts of concentrated urine.



In fresh-water fish, water regulation is the reverse of marine species. Salt is constantly being lost through the gills, and large amounts of water enter through the fish's skin and gills (Figure 2). This is because the salt concentration in a fish (approximately 0.5 percent) is higher than the salt concentration of the water in which it lives. Because the fish's body is constantly struggling to prevent the "diffusion" of water into its body, large amounts of water are excreted by the kidneys. As a result, the salt concentration of the urine is very low. By understanding the need to maintain a water balance in freshwater fish, one can understand why using salt during transport is beneficial to fish.

Figure 2. Direction of water, ammonia, and salt movement into and out of freshwater fish. Freshwater fish do not drink water, but excrete large amounts of dilute urine.



Sources of Water

Water is always a limiting factor in commercial fish production. Many of the negative chemical and environmental factors associated with most operations have their origins in the source of water selected. Final site selection has to be made based on both the quality and quantity of water available. The most common sources of water used for aquaculture are wells, springs, rivers and lakes, groundwater, and municipal water. Of the sources mentioned, wells and springs are considered consistently high quality sources (see AS-486 for more information on water sources).

Water Quantity

The beginning aquaculturist usually underestimates the quantity of water required for commercial production. **It is generally accepted that a minimum rate of 13 gallons per minute (gpm) is required for each surface acre of ponds.** With this in mind, a 100-acre fish farm will need to have wells capable of producing 1,300 gpm of water. Such large volumes are required to replace water lost to evaporation and seepage. In addition, the farmer may have several ponds to fill quickly during the spawning season. **In raceway culture, it is advisable to have a minimum flow rate of 500 gpm.** Even water recirculating systems that recycle water require large quantities of water. If a 100,000 gallon capacity water recirculating operation exchanges 10 percent of the water daily, it will require 10,000 gallons of water per day.

The availability of subsurface groundwater in Indiana and Illinois varies widely, ranging from as little as 10 gpm or less to over 2,000 gpm from properly constructed, large diameter wells. With the exception of the aquifers located along major river drainages (usually high yields), potential yields are divided into three distinct regions:

1) Northern Indiana and Illinois are good to excellent and, exclusive of some areas near northwestern Indiana, yields from 200-2,000 gpm can be expected.

2) In the central portion of Indiana and Illinois, groundwater conditions range from fair to good. Well yields from 100-400 gpm are typical for many large-diameter wells.

3) Many areas of southern Indiana and Illinois lack ground-water; generally, less than 10 gpm are available from properly constructed wells. In these areas, the major sources of groundwater are present in the sand and gravel deposits of the river valley aquifers.

These yield potentials do not indicate that an unlimited number of wells can be developed in given location. Detailed studies, including exploratory drilling and test pumping, should be conducted to adequately evaluate the groundwater resource in any given area. The resultant change in the water table is produced by spheres of influence from nearby wells.

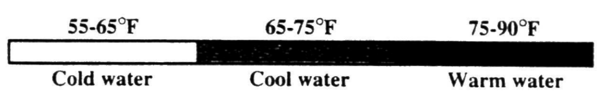
Water's Physical Factors

Temperature

After oxygen, water temperature may be the single most important factor affecting the welfare of fish. Fish are cold-blooded organisms and assume approximately the same temperature as their surroundings. The temperature of the water affects the activity, behavior, feeding, growth, and reproduction of all fishes. Metabolic rates in fish double for each 18°F rise in temperature.

Fish are generally categorized into warm water, cool water, and cold water species based on optimal growth temperatures (Figure 3).

Figure 3. General temperature ranges for cold water, cool water, and warm water species.



Channel catfish and tilapia are examples of warm water species. Their temperature range for growth is between 75-90°F. A temperature of 85°F for catfish and 87°F for tilapia is considered optimum.

Walleye and yellow perch are examples of cool water species. Ranges for optimum growth fall between 60° and 85°F. Temperatures in the upper end of this range are considered best for maximum growth for most cool water species.

Cold water species include all species of salmon and trout. The most commonly cultured cold water species in the Midwest is rainbow trout, whose optimal temperature range for growth is 48-65°F.

Ideally, species selection should be based in part on the temperature of the water supply. Any attempt to match a fish with less than ideal temperatures will involve energy expenditures for heating or cooling. This added expense will subsequently increase production costs.

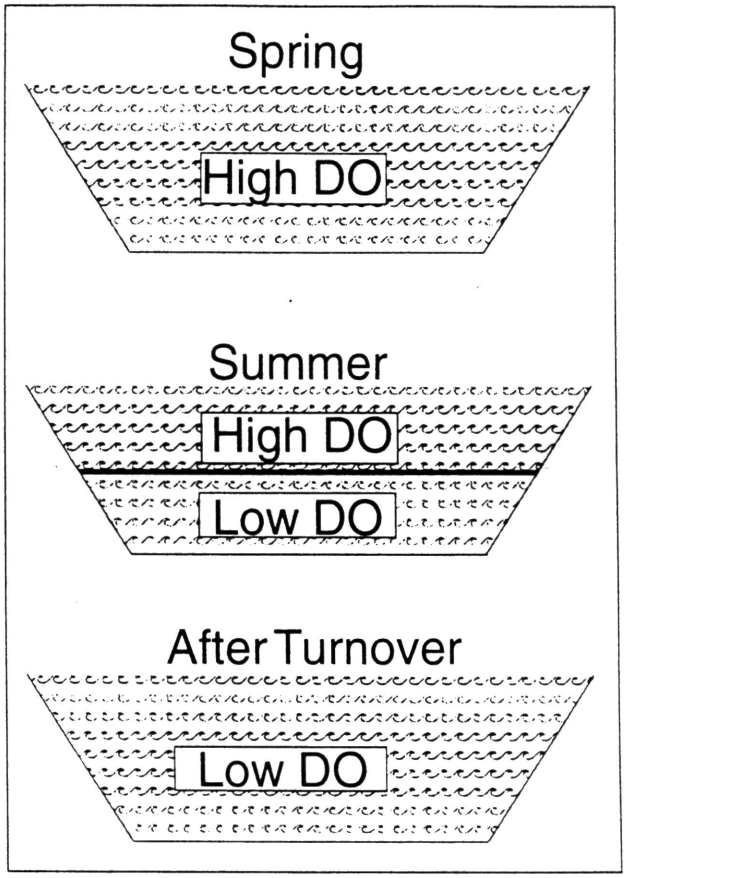
Temperature also determines the amount of dissolved gases (oxygen, carbon dioxide, nitrogen, etc.) in the water. The cooler the water the more soluble the gas. Temperature plays a major role in the physical process called thermal stratification (Figure 4). As mentioned earlier, water has a high-heat capacity and unique density qualities. Water has its maximum density at 39.2°F. In spring, water temperatures are nearly equal at all pond depths. As a result, nutrients, dissolved gases, and fish wastes are evenly mixed throughout the pond. As the days become warmer, the surface water becomes warmer and lighter while the cooler-denser water forms a layer underneath.

Circulation of the colder bottom water is prevented because of the different densities between the two layers of water. Dissolved oxygen levels decrease in the bottom layer since photosynthesis and contact with the air is reduced. The already low oxygen levels are further reduced through decomposition of waste products, which settle to the pond bottom. Localized dissolved oxygen depletion poses a very real problem to the fish farmer.

Summer stratification is a greater problem for fish raised in deeper farm ponds. Stratification may last for several weeks. This condition may develop into a major fish kill when sudden summer rains occur. These rains will cool the warmer upper layer of water enough to allow it to mix with the oxygen poor layer below. Decomposing materials in the oxygen-poor layer are again mixed evenly throughout the pond, resulting in an overall reduction in the dissolved oxygen level. Fish previously able to avoid the oxygen depleted layer are now susceptible to low-dissolved oxygen syndrome and possibly death.

Ice is another physical factor directly related to temperature. Normally, ice cover does not impede photosynthesis. Fish consume less oxygen at colder temperatures, greatly reducing the overall oxygen demand. But fish can still suffer from low-dissolved oxygen under snow covered ice. Under extended ice cover, other gases (carbon dioxide, hydrogen sulfide, methane, etc.) can build up to dangerously high levels. Mechanical aeration is probably the most reliable way of preventing an ice buildup by keeping large areas of the pond free of ice.

Figure 4. This is an illustration of seasonal changes of water temperatures which occur in fish ponds. In spring, temperatures and dissolved oxygen are uniform throughout the pond. During the summer, stratification may occur and create an upper layer of water with high-dissolved oxygen and lower layer with low-dissolved oxygen. After a rain or when a phytoplankton die-off occurs the water may turnover.



Suspended Solids

Suspended solids is a term usually associated with plankton, fish wastes, uneaten fish feeds, or clay particles suspended in the water. Suspended solids are large particles which usually settle out of standing water through time. Large clay particles are an exception. Clay particles (which will be discussed again) are kept in suspension because of the negative electrical charges associated with them.

Plankton

Turbidity caused by phytoplankton (microscopic plants) and zooplankton (microscopic animals) is not directly harmful to fish. Phytoplankton (green algae) not only produces oxygen, but also provides a food source for zooplankton and filter feeding fish/shellfish. Phytoplankton also uses ammonia produced by fish as a nutrient source. Zooplankton is a very important food source for fry and fingerlings such as hybrid striped bass and yellow perch. However, excessive amounts of algae can lead to increased rates of respiration during the night thereby consuming extra oxygen. Excessive phytoplankton buildups or "blooms" which subsequently die will also consume extra oxygen. Any wide swings between day and night oxygen levels can lead to dangerously low oxygen concentrations.

Fish Wastes

Suspended fish wastes are a serious concern for water recirculating culture systems. Large amounts of suspended and settleable solids are produced during fish production. As a rule, one pound of fish waste is produced for every pound of fish produced. Fish waste particles can be a major source of poor water quality because they may contain up to 70 percent of the nitrogen load in the system. These wastes not only irritate the fish's gills, but can cause several problems to the biological filter. The particulate waste can clog the biological filter, causing the nitrifying bacteria to die from lack of oxygen. Particulate waste can also promote the growth of bacteria that produces—rather than consumes ammonia.

Clay

Most clay turbidity problems are the result of exposed soil on the pond levee, exposed watershed, crayfish activity, or feeding of bottom dwelling species such as carp and catfish. Turbidity levels exceeding 20,000 ppm can cause behavioral changes in fish. In natural bodies of water, turbidity values seldom exceed these critical levels. Even "muddy looking" ponds rarely have concentrations greater than 2,000 ppm.

Turbidity caused by clay or soil particles, however, can restrict light penetration and limit photosynthesis. Sedimentation of soil particles may also smother fish eggs and destroy beneficial communities of bottom organisms such as bacteria.

Removal of clay turbidity can be accomplished by adding materials that attach to the negative charges of the clay particles, forming particles heavy enough to settle to the bottom. Common remedies for clay turbidity are 7-10 square bales of hay per surface acre, or 300-500 pounds of gypsum per surface acre. Gypsum applications may be repeated at two week intervals if ponds do not clear.

Water's Chemical Factors

Photosynthesis

Photosynthesis is one of the most important biological activities in standing pond aquaculture. Many water quality parameters such as dissolved oxygen, carbon dioxide, pH cycles, nitrogenous waste products are regulated by the photosynthetic reaction in phytoplankton. **Simply stated, photosynthesis is the process by which phytoplankton uses sunlight to convert carbon dioxide into a food source and to release oxygen as a by-product (Figure 5).**

Figure 5. Equation illustrating the photosynthetic process which occurs in fish ponds and produces food for phytoplankton and releases oxygen as a by-product.

$$\text{Chlorophyll of Plants} + \text{Carbon Dioxide} \xrightarrow{\text{Sunlight}} \text{food} + \text{oxygen}$$

In addition to supplying oxygen in fish ponds, photosynthesis also removes several forms of nitrogenous wastes, such as ammonia, nitrates, and urea.

The phytoplanktonic plant pigments involved in this chemical reaction are referred to as chlorophyll. These are the same pigments found in higher plants such as tree leaves.

Because the photosynthetic process is driven by sunlight, greatest concentrations of oxygen occur when the sun is highest on the horizon (usually 2-3 p.m. in the afternoon). At night, photosynthesis ceases and the phytoplankton primarily respirate.

Respiration is the reverse of photosynthesis in that oxygen is used by phytoplankton to convert food to energy and carbon dioxide is released as a by-product. Phytoplankton respiration also occurs during the day but fortunately for the fish farmer, there is usually a surplus of oxygen produced to compensate for the loss due to respiration. An exception occurs during extended periods of cloud cover. Respiration occurring in the absence of photosynthesis causes oxygen levels to decrease throughout the night. As a result, the lowest concentrations of oxygen are observed immediately prior to sunrise.

Dissolved Gases

Dissolved gases are those which are in a water solution. An example of gas dissolved in solution is soda water which has large quantities of dissolved carbon dioxide. The most common gases are oxygen, carbon dioxide, nitrogen, and ammonia. Concentrations are measured in parts per million (ppm) or milligrams per liter (mg/l), both units of measure are the same. (One ppm or mg/l is the same as one pound added to 999,999 pounds to total 1,000,000 pounds).

Oxygen

Dissolved oxygen (DO) is by far the most important chemical parameter in aquaculture. **Low-dissolved oxygen levels are responsible for more fish kills, either directly or indirectly, than all other problems combined.** Like humans, fish require oxygen for respiration. The amount of oxygen consumed by the fish is a function of its size, feeding rate, activity level, and temperature. Small fish consume more oxygen than do large fish because of their higher metabolic rate. Meade (1974) determined the oxygen consumption of salmon reared at 57°F was 0.002 pounds per pound of fish per day. Lewis et al. (1981) determined striped bass raised at 77°F consumed 0.012-0.020 pounds per pound of fish per day. The higher oxygen requirement by striped bass may be attributed to the statement that the metabolic rate doubles for each 18°F increase in temperature.

The amount of oxygen that can be dissolved in water decreases at higher temperatures and decreases with increases in altitudes and salinites (Table 1).

Table 1. Solubility of oxygen (ppm) in water at various water temperatures, salinities, and altitudes.

Variable	Water Temperature °F				
	68.0	**71.6**	**78.8**	**82.4**	**86.0**
Salinity (ppm)					
0	9.2	8.8	8.2	7.9	7.6
5,000	8.7	8.4	7.8	7.5	7.3
10,000	8.3	8.0	7.4	7.1	6.9
Altitude (ft)					
0 (Sea Level)	9.2	8.8	8.2	7.9	7.6
1,000	8.8	8.5	7.9	7.6	7.4
2,000	8.5	8.2	7.6	7.3	7.1

At sea level and zero salinity 68.0°F water can hold 9.2 ppm, while at 86.0°F, saturation is at 7.6 ppm. In combining this relationship of decreased solubility with increasing temperatures, it can be seen why oxygen depletion are so common in the summer when higher water temperatures occur.

Fish farmer, in an attempt to maximize production, stock greater amounts of fish in a given body of water than found in nature. At times during summer it may be necessary to supply supplemental aeration to maintain adequate levels of dissolved oxygen. Whereas in recirculation systems, the farmer must supply 100 percent of the oxygen needed for the fish and beneficial nitrifying bacteria.

To obtain good growth, fish must be cultured at optimum levels of dissolved oxygen. A good rule of thumb is to maintain DO levels at saturation or at least 5 ppm (Figure 6). Dissolved oxygen levels less than 5 ppm can place undue stress on the fish, and levels less than 2 ppm will result in death (possibly 3 ppm for hybrid striped bass and yellow perch). Some warmwater species such as tilapia and carp are better adapted to withstand occasional low DO levels, while most coolwater species cannot.

Figure 6. General dissolved oxygen requirements in parts per million (ppm) for fish.

Danger	**Caution**	**Safe**
Less than 3 ppm	Between 3-6	6 ppm or more

Fish are not the only consumers of oxygen in aquaculture systems, bacteria, phytoplankton, and zooplankton consume large quantities of oxygen as well. Decomposition of organic materials (algae, bacteria, and fish wastes) is the single greatest consumer of oxygen in aquaculture systems. Problems encountered from water recirculating systems usually stem from excessive ammonia production in fish wastes. Consumption of oxygen by nitrifying bacteria that break down toxic ammonia to non-toxic forms depends on the amount of ammonia entering the system. Meade (1974) determined that 4.0-4.6 pounds of oxygen are needed to oxidize every pound of ammonia. However, since other bacteria are present in pond and tank culture, a ratio of 6 pounds of oxygen to 1 pound of ammonia is recommended.

Oxygen enters the water primarily through direct diffusion at the air-water interface and through plant photosynthesis. Direct diffusion is relatively insignificant unless there is considerable wind and wave action. Several forms of mechanical aeration are available to the fish farmer. The general categories are:

- Paddlewheels
- Agitators
- Vertical sprayers
- Impellers
- Airlift pumps
- Venturia pumps
- Liquid oxygen injection
- Air diffusers

Mechanical aeration can also increase dissolved oxygen levels. Because of the lack of photosynthesis in indoor water recirculating systems, mechanical means of aeration are the only alternative for supplying oxygen to animals cultured in these systems. Oxygen depletions can be calculated, but predictions can be misleading and should never be substituted for actual measurements.

Carbon Dioxide

Carbon dioxide (CO_2) is commonly found in water from photosynthesis, or in water sources originating from limestone bearing rock. Fish can tolerate concentrations of 10 ppm provided dissolved oxygen concentrations are high. Water supporting good fish populations normally contain less than 5 ppm of free carbon dioxide. In water used for intensive pond fish culture, carbon dioxide levels may fluctuate from 0 ppm in the afternoon to 5-15 ppm at daybreak. While in recirculating systems carbon dioxide levels may regularly exceed 20 ppm, excessively high levels of carbon dioxide (greater than 20 ppm) may interfere with the oxygen utilization by the fish.

There are two common ways to remove free carbon dioxide. First, with well or spring water from limestone bearing rocks, aeration can "blow" off the excess gas. The second option is to add some type of carbonate buffering material such as calcium carbonate ($CaCO_3$) or sodium bicarbonate (Na_2CO_3). Such additions will initially remove all free carbon dioxide and store it in reserve as bicarbonate and carbonate buffers. This concept is discussed in further detail under alkalinity.

Nitrogen

Dissolved gases, especially nitrogen, are usually measured in terms of "percent saturation." Any value greater than the amount of gas the water normally holds at a given temperature constitutes supersaturation. A gas supersaturation level above 110 percent is usually considered problematic.

Gas bubble disease is a symptom of gas supersaturation. The signs of gas bubble disease can vary. Bubbles may reach the heart or brain, and fish die without any visible external signs. Other symptoms may be bubbles just under the surface of the skin, in the eyes, or between the fin rays. Treatment of gas bubble disease involves sufficient aeration to decrease the gas concentration to saturation or below.

Ammonia

Fish excrete ammonia and lesser amounts of urea into the water as wastes. Two forms of ammonia occur in aquaculture systems, ionized and un-ionized. The un-ionized form of ammonia (NH_3) is extremely toxic while the ionized form (NH_4^+) is not. Both forms are grouped together as "total ammonia." Through biological processes, toxic ammonia can be degraded to harmless nitrates (Figure 7).

Figure** 7. **Equation illustrating how toxic un-ionized ammonia (NH_3) is removed from water through the biological process called nitrification.

$$\text{Ammonia } (NH_3) \xrightarrow[\text{Nitrosomons sp.}]{O_2} \text{Nitrites } (NO_2^-) \xrightarrow[\text{Nitrobactor sp.}]{O_2} \text{Nitrates } (NO_3^-)$$

In natural waters, such as lakes, ammonia may never reach dangerous high levels because of the low densities of fish. But the fish farmer must maintain high densities of fish and, therefore, runs the risk of ammonia toxicity. Un-ionized ammonia levels rise as temperature and pH increase (Table 2).

Table 2. Percentage of total ammonia that is un-ionized at various temperatures and pH. To determine un-ionized ammonia concentration, multiply total ammonia concentration by the percentage which is closest to the observed temperature and pH of the water sample. For example, a total ammonia concentration of 5 ppm at pH 9 and 68°F would be: 5 ppm total ammonia X 28.5% = 1.43 ppm.

pH	54°F	62°F	68°F	75°F	82°F	90°F
7.0	0.2	0.3	0.4	0.5	0.7	1.0
7.4	0.5	0.7	1.0	1.3	1.7	2.4
7.8	1.4	1.8	2.5	3.2	4.2	5.7
8.2	3.3	4.5	5.9	7.7	11.0	13.2
8.6	7.9	10.6	13.7	17.3	21.8	27.7
9.0	17.8	22.9	28.5	34.4	41.2	49.0
9.2	35.2	42.7	50.0	56.9	63.8	70.8
9.6	57.7	65.2	71.5	76.8	81.6	85.9
10.0	68.4	74.8	79.9	84.0	87.5	90.6

Toxicity levels for un-ionized ammonia depend on the individual species; however, levels below 0.02 ppm are considered safe. Dangerously high ammonia concentrations are usually limited to water recirculation system or hauling tanks where water is continually recycled and in pond culture after phytoplankton die-offs. However, the intermediate form of ammonia—nitrite—has been known to occur at toxic levels (brown-blood disease) in fish ponds.

Buffering Systems

A buffering system to avoid wide swings in pH is essential in aquaculture. Without some means of storing carbon dioxide released from plant and animal respiration, pH levels may fluctuate in ponds from approximately 4-5 to over 10 during the day. In recirculating systems constant fish respiration can raise carbon dioxide levels high enough to interfere with oxygen intake by fish, in addition to lowering the pH of the water.

pH

The quantity of hydrogen ions (H^+) in water will determine if it is acidic or basic. The scale for measuring the degree of acidity is called the pH scale, which ranges from 1 to 14. A value of 7 is considered neutral, neither acidic or basic; values below 7 are considered acidic; above 7, basic. The acceptable range for fish culture is normally between pH 6.5-9.0.

Alkalinity

Alkalinity is the capacity of water to neutralize acids without an increase in pH. This parameter is a measure of the bases, bicarbonates (HCO_3^-), carbonates (CO_3^{--}) and, in rare instances, hydroxide (OH^-). Total alkalinity is the sum of the carbonate and bicarbonate alkalinities. Some waters may contain only bicarbonate alkalinity and no carbonate alkalinity.

The carbonate buffering system is important to the fish farmer regardless of the production method used. In pond production, where photosynthesis is the primary natural source of oxygen, carbonates and bicarbonates are storage area for surplus carbon dioxide. By storing carbon dioxide in the buffering system, it is never a limiting factor that could reduce photosynthesis, and in turn, reduce oxygen production. Also, by storing carbon dioxide, the buffering system prevents wide daily pH fluctuations.

Without a buffering system, free carbon dioxide will form large amounts of a weak acid (carbonic acid) that may potentially decrease the night-time pH level to 4.5. During peak periods of photosynthesis, most of the free carbon dioxide will be consumed by the phytoplankton and, as a result, drive the pH levels above 10. As discussed, fish grow within a narrow range of pH values and either of the above extremes will be lethal to them.

In recirculating systems where photosynthesis is practically non-existent, a good buffering capacity can prevent excessive buildups of carbon dioxide and lethal decreases in pH. It is recommended that the fish farmer maintain total alkalinity values of **at least** 20 ppm for catfish production. Higher alkalinities of at least 80-100 ppm are suggested for hybrid striped bass. For water supplies that have naturally low alkalinities, agriculture lime can be added to increase the buffering capacity of the water.

Hardness

Water hardness is similar to alkalinity but represents different measurements. Hardness is chiefly a measure of calcium and magnesium, but other ions such as aluminum, iron, manganese, strontium, zinc, and hydrogen ions are also included. When the hardness level is equal to the combined carbonate and bicarbonate alkalinity, it is referred to as carbonate hardness. Hardness values greater than the sum of the carbonate and bicarbonate alkalinity are referred to as non-carbonated hardness. Hardness values of **at least** 20 ppm should be maintained for optimum growth of aquatic organisms. Low hardness levels can be increased with the addition of ground agriculture lime.

Other Metals and Gases

Other metals such as iron and sodium, and gases, such as hydrogen sulfide, may sometimes present special problems to the fish farmer. Most complications arising from these can be prevented by properly pre-treating the water prior to adding it to ponds or tanks. The range of treatments may be as simple as aeration, which removes hydrogen sulfide gas, to the expensive use of iron removal units. Normally iron will precipitate out of solution upon exposure to adequate concentrations of oxygen at a pH greater than 7.0.

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Appendix 1

TABLE 3 Suggested water-quality criteria for aquaculture hatcheries or production facilities. Salmonid quality standards with modification for warmwater situations. Concentrations are in ppm (mg/1). (Source: Modification from Wedemeyer, 1977; Piper, etc al. (Larsen), 1982)

Chemical	Upper Limits for Continuous Exposure and/or Tolerance Ranges
Ammonia (NH_3)	0.0125 ppm (un-ionized form)
Cadmium[a]	0.004 ppm (soft water < 100 ppm alkalinity)
Cadmium[b]	0.003 ppm (hard water > 100 ppm alkalinity)
Calcium	4.0 to 160 ppm (10.0-160.00 ppm[d])
Carbon dioxide	0.0 to 10 ppm (0.0-15.0 ppm[d])
Cholorine	0.03 ppm
Copper[c]	0.006 in soft water
Hydrogen sulfide	0.002 ppm (Larsen - 0.0 ppm)
Iron (total)	0.0 to 0.15 ppm (0.0-0.5 ppm[d])
Ferrous ion	0.00 ppm
Ferric ion	0.5 ppm (0.0-0.5 ppm[d])
Lead	0.03 ppm
Magnesium	(Needed for buffer system)
Manganese	0.0 to 0.01 ppm
Mercury (organic of inorganic)	0.002 ppm maximum, 0.00005 ppm average
Nitrate (NO^-_3)	0.0 to 3.0 ppm
Nitrite (NO^-_2)	0.1 ppm in soft water, 0.2 ppm in hard water 0.03 and 0.06 ppm nitrite-nitrogen
Nitrogen	Maximum total gas pressure 110% of saturation
Oxygen	5.0 ppm to saturation; 7.0 to saturation for eggs or broodstock
Ozone	0.005 ppm
pH	6.5 to 8.0 (6.6-9.0[d])
Phosphorus	0.01 to 3.0 ppm
Polychlorinated biphenyls (PCBs)	0.002
Total suspended and settleable solids	80.0 ppm or less
Total Alkalinity (as $CaCO_3$)	10.0 to 400 ppm (50.0-4.00.0 ppm[d])
% as phenolphthalein	0.0 to 25 ppm (0.40 ppm[d])
% as methyl orange	75 to 100 ppm (60.0-100.0 ppm[d])
% as ppm hydroxide	0.0 ppm
% as ppm carbonate	0.0 to 25 ppm (0.0-40.0 ppm[d])
% as ppm bicarbonate	75 to 100 ppm
Total Hardness (as $CaCO_3$)	10 to 400 ppm (50.0-400.0 ppm[d])
Zinc	0.03-0.05 ppm

[a] To protect salmonid eggs and fry. For non-salmonids 0.004 ppm is acceptable
[b] To protect salmonid eggs and fry. For non-salmonids 0.03 ppm is acceptable
[c] Copper at 0.005 ppm may suppress gill adensione triphosphatase and compromise smoltification in anadromous salmonids.
[d] Warm water situations

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Revised

Recirculating Aquaculture Tank Production Systems

An Overview of Critical Considerations

Thomas M. Losordo[1], Michael P. Masser[2] and James Rakocy[3]

Traditional aquaculture production in ponds requires large quantities of water. Approximately 1 million gallons of water per acre are required to fill a pond and an equivalent volume is required to compensate for evaporation and seepage during the year. Assuming an annual pond yield of 5,000 pounds of fish per acre, approximately 100 gallons of water are required per pound of fish production. In many areas of the United States, traditional aquaculture in ponds is not possible because of limited water supplies or an absence of suitable land for pond construction.

Recirculating aquaculture production systems may offer an alternative to pond aquaculture technology. Through water treatment and reuse, recirculating systems use a fraction of the water required by ponds to produce similar yields. Because recirculating systems usually use tanks for aquaculture production, substantially less land is required.

Aquatic crop production in tanks and raceways where the environment is controlled through water treatment and recirculation has been studied for decades. Although these technologies have been costly, claims of impressive yields with year-round production in locations close to major markets and with extremely little water usage have attracted the interest of prospective aquaculturists. In recent years, a variety of production facilities that use recirculating technology have been built. Results have been mixed. While there have been some notable large-scale business failures in this sector, numerous small- to medium-scale efforts continue production.

Prospective aquaculturists and investors need to be aware of the basic technical and economic risks involved in this type of aquaculture production technology. This fact sheet and others in this series are designed to provide basic information on recirculating aquaculture technology.

Critical production considerations

All aquaculture production systems must provide a suitable environment to promote the growth of the aquatic crop. Critical environmental parameters include the concentrations of dissolved oxygen, un-ionized ammonia-nitrogen, nitrite-nitrogen, and carbon dioxide in the water of the culture system. Nitrate concentration, pH, and alkalinity levels within the system are also important. To produce fish in a cost-effective manner, aquaculture production systems must maintain good water quality during periods of rapid fish growth. To ensure such growth, fish are fed high-protein pelleted diets at rates ranging from 1.5 to 15 percent of their body weight per day depending upon their size and species (15 percent for juveniles, 1.5 percent for market size).

Feeding rate, feed composition, fish metabolic rate and the quantity of wasted feed affect tank water quality. As pelleted feeds are introduced to the fish, they are either consumed or left to decompose within the system. The by-

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products of fish metabolism include carbon dioxide, ammonia-nitrogen, and fecal solids. If uneaten feeds and metabolic by-products are left within the culture system, they will generate additional carbon dioxide and ammonia-nitrogen, reduce the oxygen content of the water, and have a direct detrimental impact on the health of the cultured product.

In aquaculture ponds, proper environmental conditions are maintained by balancing the inputs of feed with the assimilative capacity of the pond. The pond's natural biological productivity (algae, higher plants, zooplankton and bacteria) serves as a biological filter that processes the wastes. As pond production intensifies and feed rates increase, supplemental and/or emergency aeration are required. At higher rates of feeding, water must be exchanged to maintain good water quality. The carrying capacity of ponds with supplemental aeration is generally considered to be 5,000 to 7,000 pounds of fish per acre (0.005 to 0.007 pound of fish per gallon of pond water).

The carrying capacity of tank systems must be high to provide for cost-effective fish production because of the higher initial capital costs of tanks compared to earthen ponds. Because of this expense and the limited capacity of the "natural" biological filtration of a tank, the producer must rely upon the flow of water through the tanks to wash out the waste by-products. Additionally, the oxygen concentration within the tank must be maintained through continuous aeration, either with atmospheric oxygen (air) or pure gaseous oxygen.

The rate of water exchange required to maintain good water quality in tanks is best described using an example. Assume that a 5,000-gallon production tank is to be maintained at a culture density of 0.5 pound of fish per gallon of tank volume. If the 2,500 pounds of fish are fed a 32% protein feed at a rate of 1.5 percent of their body weight per day, then 37.5 pounds of feed would produce approximately 1.1 pounds of ammonia-nitrogen per day. (Approximately 3 percent of the feed becomes ammonia-nitrogen.) Additionally, if the ammonia-nitrogen concentration in the tank is to be maintained at 1.0 mg/l, then a mass balance calculation on ammonia-nitrogen indicates that the required flow rate of new water through the tank would be approximately 5,600 gallons per hour (93 gpm) to maintain the specified ammonia-nitrogen concentration. Even at this high flow rate, the system also would require aeration to supplement the oxygen added by the new water.

Recirculating systems design

Recirculating production technology is most often used in tank systems because sufficient water is not available on site to "wash" fish wastes out of production tanks in a flow-through configuration or production system that uses water only once. In most cases, a flow-through requirement of nearly 100 gallons per minute to maintain one production tank would severely limit production capacity. By recirculating tank water through a water treatment system that "removes" ammonia and other waste products, the same effect is achieved as with the flow-through configuration. The efficiency with which the treatment system "removes" ammonia from the system, the ammonia production rate, and the desired concentration of ammonia-nitrogen within the tank determine the recirculating flow rate from the tank to the treatment unit. Using the example outlined above, if a treatment system removes 50 percent of the ammonia-nitrogen in the water on a single pass, then the flow rate from the tank would need to be twice the flow required if fresh water were used to flush the tank (93 gpm/0.5 = 186 gpm).

A key to successful recirculating production systems is the use of cost-effective water treatment system components. All recirculating production systems remove waste solids, oxidize ammonia and nitrite-nitrogen, remove carbon dioxide, and aerate or oxygenate the water before returning it to the fish tank (see Fig. 1). More intensive systems or systems culturing sensitive species may require additional treatment processes such as fine solids removal, dissolved organics removal, or some form of disinfection.

Waste solids constraints

Pelleted feeds used in aquaculture production consist of protein, carbohydrates, fat, minerals and water. The portion not assimilated by the fish is excreted as a highly organic waste (fecal solids). When broken down by bacteria within the system, fecal solids and uneaten feed will consume dissolved oxygen and generate ammonia-nitrogen. For this reason, waste solids should be removed from the system as quickly as possible. Waste solids can be classified into four categories: settleable, suspended, floatable and dissolved solids. In recirculating systems, the first two are of primary concern. Dissolved organic solids can become a problem in systems with very little water exchange.

Settleable solids control: Settleable solids are generally the easiest of the four categories to deal with and should be removed from the tank and filtration components as rapidly as possible. Settleable solids are those that will generally settle out of the water within 1 hour under still conditions. Settleable solids can be removed as they accumulate on the tank bottom through proper placement of drains, or they can be kept in suspension with continuous agitation and removed with a sedimentation tank (clarifier), mechanical filter (granular or screen), or swirl separator. The sedimentation and swirl separator processes can be enhanced by adding steep incline tubes (tube

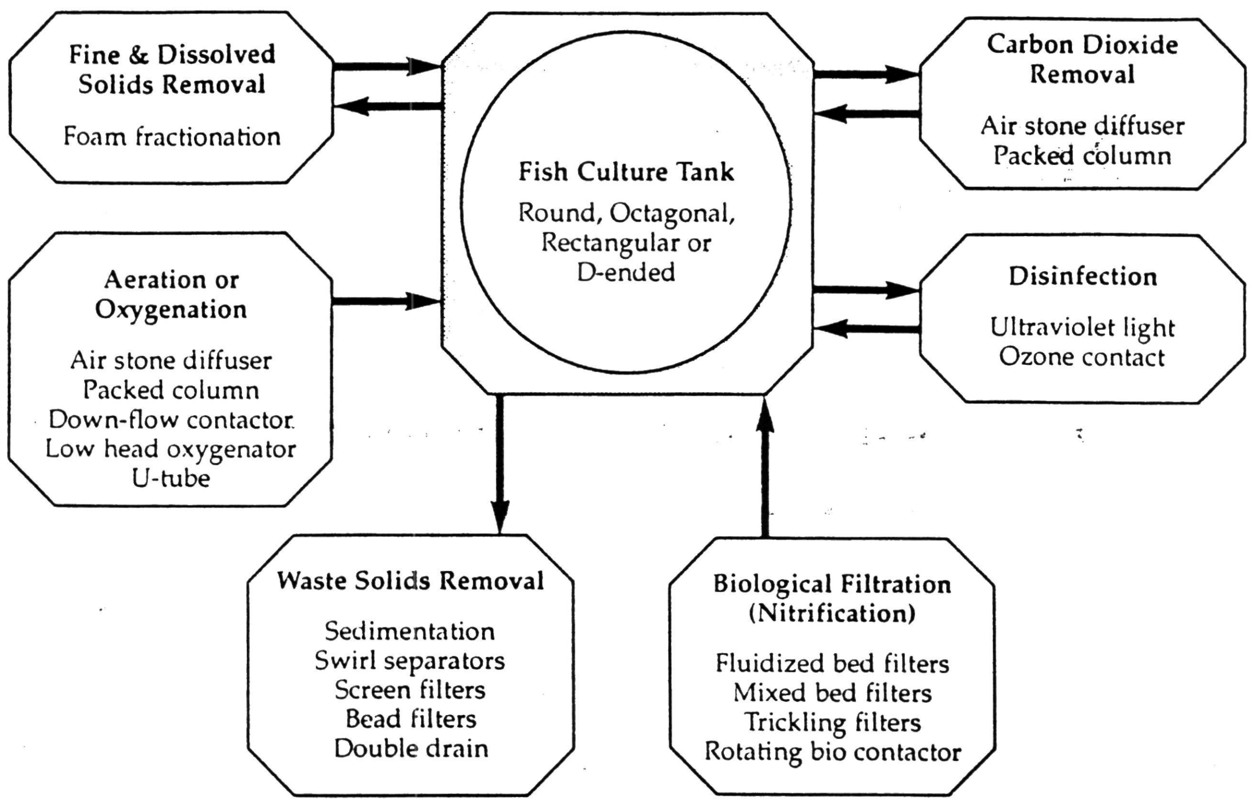

Figure 1. Required unit processes and some typical components used in recirculating aquaculture production systems.

settlers) in the sedimentation tank to reduce flow turbulence and promote uniform flow distribution.

Suspended solids control: From an aquacultural engineering point of view, the difference between suspended solids and settleable solids is a practical one. Suspended solids will not settle to the bottom of the fish culture tank and cannot be removed easily in conventional settling basins. Suspended solids are not always dealt with adequately in a recirculating production system. If not removed, suspended solids can significantly limit the amount of fish that can be grown in the system and can irritate the gills of fish. The most popular treatment method for removing suspended solids generally involves some form of mechanical filtration. The two types of mechanical filtration most commonly used are screen filtration and granular media filtration (sand or pelleted media). For more information on these devices see SRAC 453, *Recirculating Aquaculture Tank Production Systems: A Review of Component Options.*

Fine and dissolved solids control: Fine suspended solids (< 30 micrometers) have been shown to contribute more than 50 percent of the total suspended solids in a recirculating system. Fine suspended solids increase the oxygen demand of the system and cause gill irritation and damage in finfish. Dissolved organic solids (protein) can contribute significantly to the oxygen demand of the total system.

Fine and dissolved solids cannot be easily or economically removed by sedimentation or mechanical filtration technology. Foam fractionation (also referred to as protein skimming) is successful in removing these solids from recirculating tank systems. Foam fractionation, as employed in aquaculture, is a process of introducing air bubbles at the bottom of a closed column of water that creates foam at the top air/water interface. As the bubbles rise through the water column, solid particles attach to the bubbles' surfaces, forming the foam at the top of the column. The foam build-up is then channelled out of the fractionation unit to a waste collection tank. Solids concentration in the waste tank can be five times higher than that of the culture tank. Although the efficiency of foam fractionation is subject to the chemical properties of the water, the process generally can be used to significantly reduce water turbidity and oxygen demand of the culture system.

Nitrogen constraints

Total ammonia-nitrogen (TAN), consisting of un-ionized ammonia (NH_3) and ionized ammonia (NH_4^+), is a by-product of protein metabolism. TAN is excreted from the gills of fish as they assimilate feed and is produced when bacteria decompose organic waste solids within the system. The un-ionized form of ammonia-nitrogen is extremely toxic to most fish. The fraction of TAN in the un-ionized form is dependent upon the pH and temperature of the water. At a pH of 7.0, most of the TAN is in the ionized form, while at a pH of 8.75 up to 30 percent of TAN is in the un-ionized form. While the lethal concentration of ammonia-nitrogen for many species has been established, the sub-lethal effects of ammonia-nitrogen have not been well defined. Reduction in growth rates may be the most important sub-lethal effect. In general, the concentration of un-ionized ammonia-nitrogen in tanks should not exceed 0.05 mg/l.

Nitrite-nitrogen (NO_2^-) is a product of the oxidation of ammonia-nitrogen. Nitrifying bacteria (*Nitrosomonas*) in the production system utilize ammonia-nitrogen as an energy source for growth and produce nitrite-nitrogen as a by-product. These bacteria are the basis for biological filtration. The nitrifying bacteria grow on the surface of the biofilter substrate although all tank production system components will have nitrifying bacteria present to some extent. While nitrite-nitrogen is not as toxic as ammonia-nitrogen, it is harmful to aquatic species and must be controlled within the tank.

Nitrite-nitrogen binds with hemoglobin to produce methemoglobin. Methemoglobin is not capable of binding and transporting oxygen and the affected fish become starved for oxygen. The toxicity of nitrite-nitrogen is species specific. However, a common practice for reducing nitrite-nitrogen toxicity is to increase the chloride concentration of the culture water. Maintaining a chloride to nitrite-nitrogen ratio of 10:1 generally will protect against methemoglobin build-up and nitrite-nitrogen toxicity. Fortunately, *Nitrobacter* bacteria, which also are present in most biological filters, utilize nitrite-nitrogen as an energy source and produce nitrate as a by-product. In a recirculating system with a mature biofilter, nitrite-nitrogen concentrations should not exceed 10 mg/l for long periods of time and in most cases should remain below 1 mg/l.

Nitrates are not generally of great concern to the aquaculturist. Studies have shown that aquatic species can tolerate extremely high levels (> 200 mg/l) of nitrate-nitrogen in production systems. Nitrate-nitrogen concentrations do not generally reach such high levels in recirculating systems. Nitrate-nitrogen is either flushed from a system during system maintenance operations (such as settled solids removal or filter backwashing), or denitrification occurs within a treatment system component such as a settling tank. Denitrification occurs when anaerobic bacteria metabolize nitrate-nitrogen to produce nitrogen gas that is released to the atmosphere during the aeration process. For more information on the effects of water quality on fish production, see SRAC 452, *Recirculating Aquaculture Tank Production Systems: Management of Recirculating Systems.*

Ammonia and nitrite-nitrogen control: Controlling the concentration of un-ionized ammonia-nitrogen (NH_3) in the culture tank is a primary objective of recirculating treatment system design. Ammonia-nitrogen must be "removed" from the culture tank at a rate equal to the rate of production to maintain a safe concentration. While there are a number of technologies available for removing ammonia-nitrogen from water, biological filtration is the most widely used. In biological filtration (also referred to as biofiltration), there is a substrate with a large surface area where nitrifying bacteria can attach and grow. As previously noted, ammonia and nitrite-nitrogen in the recycle stream are oxidized to nitrite and nitrate-nitrogen by *Nitrosomonas* and *Nitrobacter* bacteria, respectively. Gravel, sand, plastic beads, plastic rings, plastic tubes, and plastic plates are common biofiltration substrates. The configuration of the substrate and the manner in which it comes into contact with wastewater define the water treatment characteristics of the biological filtration unit. The most common configurations for biological filters include rotating biological contactors (RBC), fixed film reactors, expandable media filters, and mixed bed reactors. For more information on biological filters and components see SRAC 453, *Recirculating Aquaculture Tank Production Systems: A Review of Component Options.*

pH and alkalinity constraints

The measure of the hydrogen ion (H^+) concentration, or pH, in water indicates the degree to which water is either acidic or basic. The pH of water affects many other water quality parameters and the rates of many biological and chemical processes. Thus, pH is considered an important parameter to be monitored and controlled in recirculating aquaculture systems. Alkalinity is a measure of the water's capacity to neutralize acidity (hydrogen ions). Bicarbonate (HCO_3^-) and carbonate (CO_3^-) are the predominant bases or sources of alkalinity in most waters. Highly alkaline waters are more strongly buffered against pH change than less alkaline waters.

Nitrification is an acid-producing process. As ammonia-nitrogen is transformed to nitrate-nitrogen by nitrifying bacteria, hydrogen ions are produced. As hydrogen ions combine with bases such as hydroxide (OH-), carbonate and bicarbonate, alkalinity is consumed and the pH decreases. Levels of pH below 4.5 are dangerous to fish; a pH below 7.0 will reduce the activity of nitrifying bacteria. If the source water for a recirculating system is low in alkalinity, then pH and alkalinity should be monitored and alkalinity must be maintained with additions of bases. Some bases commonly used include hydrated lime [$Ca(OH)_2$] quick lime (CaO), and sodium bicarbonate ($NaHCO_3$).

Dissolved gas constraints

Although ammonia-nitrogen build-up can severely limit a recirculating system's carrying capacity, maintaining adequate dissolved oxygen (DO) concentrations in the culture tank and filter system also is of critical importance. In most cases, a system's ability to add dissolved oxygen to water will become the first limiting factor in a system's fish carrying capacity. To maintain adequate DO levels in the culture tank, oxygen must be added to the tank at a rate equal to that of the rate of consumption by fish and bacteria. The consumption rate of dissolved oxygen in a recirculating system is difficult to calculate, yet an estimate is essential for proper system design. The overall rate of oxygen consumption for a system is the sum of the respiration rate of the fish, the oxygen demand of bacteria breaking down organic wastes and uneaten food (also referred to as Biochemical Oxygen Demand or BOD), and the oxygen demand of nitrifying bacteria in the filter. The amount of oxygen required by the system is largely dictated by the length of time waste solids remain within the system and the biofilter configuration. In systems with non-submerged biofilters, where solids are removed quickly, as little as 0.3 pound of oxygen can be consumed for every pound of feed added. In systems with submerged biological filters, where solids are retained within the system between backwashings of solid-removing filters, as much as 0.75 pound of oxygen will be consumed for every pound of feed added.

Carbon dioxide (CO_2) is a by-product of fish and bacterial respiration and it can accumulate within recirculating systems. Elevated carbon dioxide concentrations in the water are not highly toxic to fish when sufficient dissolved oxygen is present. However, for most species, free carbon dioxide concentrations in the culture tank should be maintained at less than 20 mg/l to maintain good growing conditions.

The build-up of dissolved nitrogen gas is rarely a problem in warm water aquaculture systems. However, caution is advised when pressurized aeration or oxygenation systems are used because atmospheric nitrogen can become supersaturated in water if air is entrained into the pressurized flow stream. Aquatic organisms subjected to elevated concentrations of dissolved nitrogen gas can develop "gas bubbles" in their circulatory systems and die.

Maintaining adequate dissolved oxygen levels and minimizing carbon dioxide concentrations in the culture tank cannot be overlooked in recirculating system design. In a typical intensively loaded recirculating system, aeration or oxygenation system failure can lead to a total loss of the fish crop in 1/2 hour or less.

Aeration and Degassing: The addition of atmospheric oxygen to water or the release of excess carbon dioxide from water can be accomplished in recirculating systems through a variety of devices such as air diffusers, surface agitators, and pressurized or non-pressurized packed columns. System aeration is commonly carried out in the culture tanks, although this is not a particularly good place to add dissolved oxygen. This is because the oxygen transfer efficiency of aerators drops as the concentration of dissolved oxygen increases to near saturation levels in the tank water. Because saturated conditions are desirable in the culture tank, aeration in this location is extremely inefficient.

In recirculating systems, a better place to aerate and degas water is in the recycled flow-stream just prior to re-entry into the culture tank. At this location, in systems using submerged biological filtration, the concentration of dissolved oxygen should be at its lowest and carbon dioxide concentration will be at its highest. Packed column aerators (PCAs) are an effective and simple means of aerating water that is already in a flow-stream. In a PCA, water low in oxygen is introduced into a small tower filled with plastic medium. A perforated plate or spray nozzle evenly distributes the incoming water over the medium. The packed column is operated under non-flooded conditions so that air exchange through the tower is maintained. If the PCA is to be used for carbon dioxide stripping, a low pressure air blower will be required to provide a large quantity of air flow through the packed medium.

A number of recirculating system designs use air-lift pumps (vertical pipes with air injection) to recycle water through treatment processes and back to the culture tank. Air lifts agitate the water with air bubbles in the process and remove CO_2 and add dissolved oxygen.

Pure Oxygen Injection: In intensive production systems, the rate of oxygen consumption by the fish and bacteria may exceed the capabilities of typical aeration equipment to diffuse atmospheric oxygen into the water. In these cases, pure gaseous oxygen diffusion is used to increase the rate of oxygen addition and allow for a higher oxygen utilization rate. The saturation concentration of atmospheric oxygen in water rarely exceeds 8.75 mg/l in warm water applications (> 20° C). When pure oxygen is used with gas diffusion systems, the saturation concentration of oxygen in water is increased nearly five fold to 43 mg/l at standard atmospheric pressure. This condition allows for more rapid transfer of oxygen into water even when the ambient tank dissolved oxygen concentration is maintained close to atmospheric saturation (> 7 mg/l).

A measure of success in using pure oxygen in aquaculture is the oxygen absorption efficiency of the injection or diffusion equipment. The absorption efficiency is defined as the ratio of the weight of oxygen absorbed by the water to the weight of oxygen applied through the diffusion or injection equipment. Properly designed oxygen diffusion devices can produce an oxygen absorption efficiency of more than 90 percent. However, as with tank aeration (with air), the culture tank is not the best location for oxygen diffusion with common "air stone" diffusers. Because of the short contact time of bubbles rising through a shallow (< 6 feet) water column in tanks, air stone diffusers have oxygen absorption efficiencies of not greater than 40 percent. Efficient oxygen injection systems are designed to maximize both the oxygen/water contact area and time. This can be achieved through the use of a counter-current contact column, a closed packed-column contact unit, a u-tube column or a downflow bubble contactor. For more information on aeration and oxygenation equipment see SRAC 453, *Recirculating Aquaculture Tank Production Systems: Component Options*.

Other production considerations

There have not been many well-documented successes in large-scale fish production in recirculating systems. Most reports of successful production have been from producers who supply fish live or on ice to local niche markets. These high-priced markets appear to be necessary for financial success due to the high cost of fish production in recirculating systems. In fact, the variable costs (feed, fingerling, electricity and labor) of producing fish in recirculating systems is not much different than other production methods. Where pond culture methods require a great deal of electricity (at least 1 kW per acre of pond) for aeration during the summer months, recirculating systems have a steady electrical load over the entire year. While it may appear that recirculating systems require more labor in system upkeep and maintenance than ponds, when the long hours of nightly labor for checking oxygen in ponds and moving emergency aerators and harvest effort are considered, the difference is minimal. Recirculating systems can actually have an advantage in reducing feed costs. Tank production systems generally yield better feed conversion ratios than pond systems.

Why, then, are production costs generally higher for recirculating systems? The answer usually can be found when comparing the capital cost of these systems.

Comparing the investment costs of recirculating systems with other production methods is critical in making an informed economic evaluation. Construction costs of pond production systems in the Southeast are approximately 90 cents per pound of annual production. Recirculating systems, on the other hand, cost between $1 and $4 per pound of annual production. A $1 increase in investment cost per pound of annual production can add more than 10 cents per pound to the production cost of fish.

Given these conditions, producers using recirculating technology generally do not attempt to compete in the same markets as pond producers. However, in specialty high-value niche markets, such as gourmet foods, tropical or ornamental fish, or year-round supply of fresh product, recirculating system products are finding a place. The key to niche market success is to identify the market size and meet commitments before market expansion. In most cases, niche markets will limit the size of the production units.

Before investing in recirculating systems technology, the prospective aquaculturist should visit a commercial system and learn as much about the technology as possible. As in all aquaculture enterprises, the decision to begin production and the size of the production unit one chooses should be based on the market.

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Site Selection of Levee-type Fish Production Ponds

Thomas L. Wellborn*

Considerable thought and planning should go into selecting sites for commercial fish production ponds. Construction costs, ease and cost of operation, and productivity can be greatly affected by the site selected.

Selection of pond sites on flat land would seem to be a simple matter but many factors are involved. These alternatives must be considered, or you may find the cost and problems associated with production prohibitive with respect to profits.

Water availability

Water for filling levee-type ponds must come from a well, spring, reservoir or stream since there is no watershed for runoff water to enter the pond. Thus, one of the first considerations in selecting a site for commercial fish ponds is to make sure that an adequate supply of suitable quality water is available for the size farm planned.

Usually one well with a capacity of 2,000 to 3,000 gallons per minute (gpm) is adequate for four 20-acre ponds, or a minimum of 25 gpm per acre of pond surface. There must be enough water available to fill the pond completely within 10 days, otherwise problems with vegetation and water quality management will occur. Table 1 gives the time required to pump different volumes of water at different pumping rates.

A local well drilling company, a ground water geologist, or the closest office of the U.S. Geological Survey should be able to tell you if a well of the desired capacity can be developed at the site. Information on the quality of ground water at the site should be available from the U.S. Geological Survey or local ground water geologist.

Water sources

Water for levee ponds for commercial fish production can come from a well, spring, stream or reservoir. Of the four choices, a well is usually the best for several reasons. A spring is almost as good. Streams and reservoirs should be used only as last resorts because they usually contain various species of wild fish that can get into the pond and cause severe management problems. Streams and reservoirs can also become contaminated with pesticides or industrial chemicals that could kill fish. During droughts water levels become so low in the streams and reservoirs that they can no longer be used as sources of needed pond water. Wild fish in streams and reservoirs serve as constant sources of reinfection with various infectious diseases. The quality of water in streams and reservoirs can change enough during droughts or floods as to be unusable at those times.

If a stream or reservoir must be used as a source of water for commercial fish ponds, be aware of potential problems. Appropriate actions may need to be taken to avoid fish loss or additional expenditure of funds.

Soil characteristics

The soil must hold water, so clay-type soils are desirable. Take soil cores at various places around the site to insure adequate clay is present to prevent excess seepage. The local Soil Conservation Service Office can assist you. Ponds can be built in soils that have high percolation rates if they are lined with a layer of packed clay or plastic, but costs are almost prohibitive.

* University of Florida.

Table 1. Time in hours required to pump different volumes of water in acre feet at four different pumping rates.

Pumping Rate	Volume in Acre Feet[1] 1	5	10	70[2]
	Hours			
500 gpm	10.9	54.3	108.6	760 (31.6)[3]
1,000 gpm	5.4	27.0	54.3	380 (15.8)[3]
2,000 gpm	2.7	13.5	27.2	190 (7.9)[3]
3,000 gpm	1.8	9.0	18.1	127 (5.3)[3]

[1] 1 acre foot = 325,850 gallons = surface acre that is one foot deep.

[2] The number of acre feet of water in a pond with 17.5 surface acres with an average depth of 4 feet.

[3] Number of days required to pump that volume of water.

Topography

The topography or lay-of-the-land determines the amount of dirt that has to be moved during pond construction. Pond construction on flat land requires less dirt moving than building on rolling or hilly land. Levee-type ponds built on flat land usually require about 1,100 to 1,200 yards of dirt to be moved per acre, although the actual amount of dirt that must be moved can vary greatly from this figure.

Wetlands

Before selecting the site be sure the land is not classified as a wetland. A permit is required from the Corps of Engineers before clearing or building on **wetlands.** In some states, particularly Florida, permits are needed from one or more state agencies before any clearing or building can take place on wetlands.

Wetlands are defined as: "Those areas that are inundated or saturated by surface or ground water at a frequency and duration to support, and that under normal conditions do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas."

Draining

For management purposes and for harvesting you must be able to drain the ponds, and the site should be selected with this in mind. You must be able to drain the ponds by gravity flow, and insure that draining your ponds will not cause flooding on a neighbor's land or block the drainage from a neighbor's land.

Flooding

Make sure the site under consideration is not subject to periodic flooding. This can be done by checking with the local U.S. Geological Survey Office or Soil Conservation Service Office.

Utility right-of-ways

Before building ponds over pipe lines or under power lines, check locations of right-of-ways with the utility company first to avoid possible legal problems later.

Pesticides

Check the soil for pesticide residues if row crops were ever grown on or adjacent to the site being considered. There are three areas within a site that must be checked for pesticide residue levels. These are:

- low areas where run-off collects;
- any area where spray equipment, either aerial or ground, was filled with pesticides; and
- any area in the site where pesticides were disposed of or were stored.

Chlorinated hydrocarbon pesticides--particularly toxaphene which was widely used in the past as an insecticide in row crop farming--are long lasting in the soil. High soil concentrations of toxaphene in ponds can harm fish either through direct, acute toxicity or by chronic toxicity due to bioaccumulation. Observation seems to indicate that soil concentrations in excess of 0.5 parts per million (ppm) or milligrams per liter (mg/l) can be harmful to fish. Most chlorinated hydrocarbon pesticides are tied up in the top 2 to 4 inches of soil, depending on the type of farming practices used. Samples for analysis should be taken at a depth not to exceed 4 inches. If the top layer of soil contains high levels of pesticides while the soil deeper than 4 inches is pesticide free, the top layer of contaminated soil can be moved off and incorporated in the **outside levees only.** Do not use the contaminated soil in outside levees if planned expansion will utilize these outside levees as future inside levees.

Analysis of soils for pesticide residues can be done by commercial analytical laboratories or, in some states, by your State Chemical Laboratory. Check with your local county Extension agent to see if a state agency offers this service.

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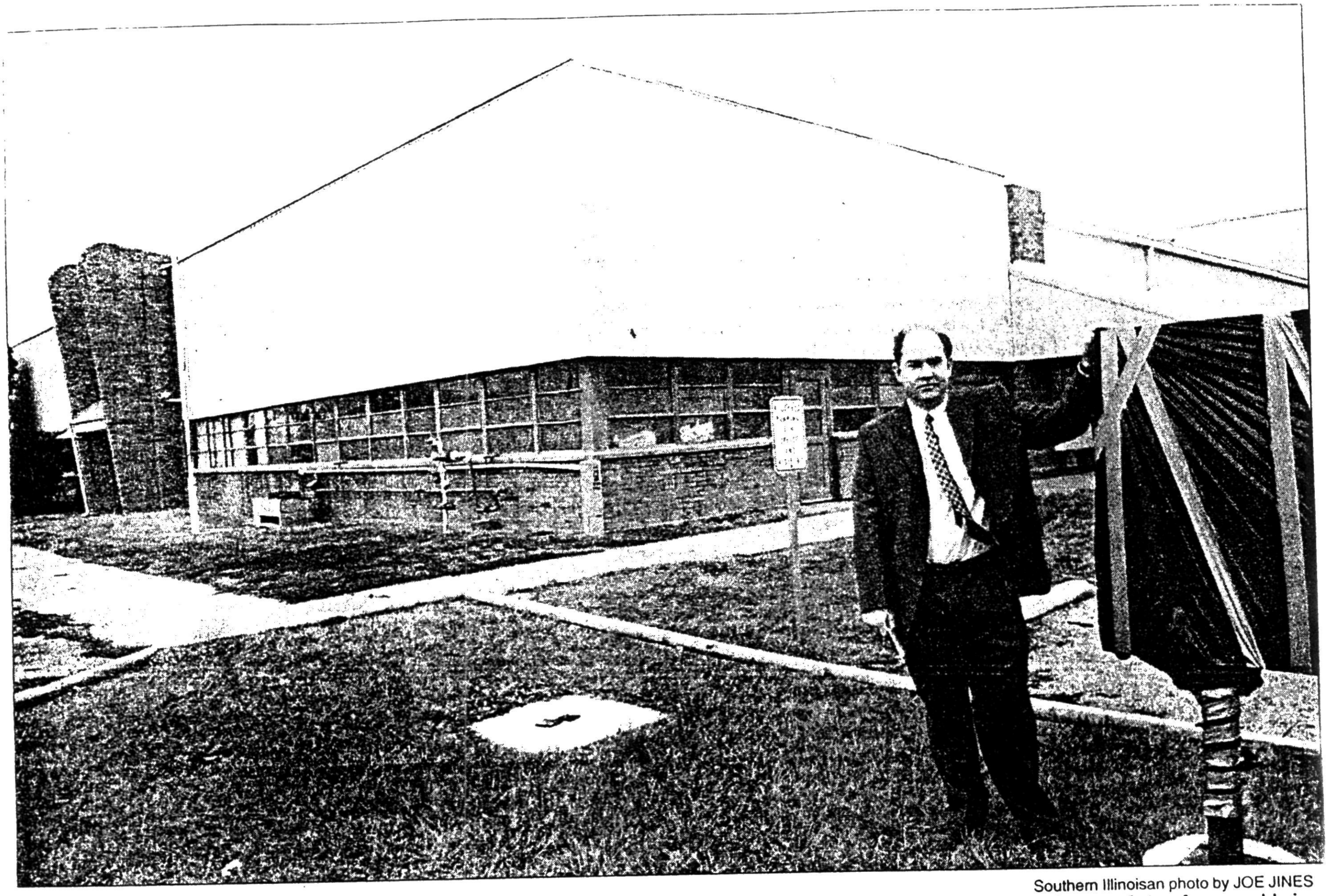

Southern Illinoisan photo by JOE JINES

FISH co-op: Steve Killian, executive director of the Illinois Fish Farmers Cooperative, stands in front of the former Universal Distribution Return Center, which will undergo renovation into the home of the co-op.

▶ILLINOIS FISH FARMERS COOPERATIVE IN PINCKNEYVILLE

Home found for fish co-op

By Karen Binder
The Southern Illinoisan

There will be no other fish processing plant in the country like the one the Illinois Fish Farmers Cooperative has planned off Illinois 154 in Pinckneyville.

Co-op executive director Steve Killian announced Wednesday that the co-operative expects to start operations by fall 2000 at its first facility in the former Universal Distribution Return Center. While other plants are designed to specifically handle one type of fish, this will be the nation's first multi-species plant.

The 48,000-square-foot building will undergo a $2 million renovation to retrofit the space with food processing lines, live fish tanks and warehouse freezers and several shipping docks for live fish deliveries from fish farmers in the four-state area. Co-op officials next week are interviewing a local engineering firm that indicated an interest in the project.

"We can truly grow into this building," Killian commented. "This is a process that will take some time. We want the best. We want to do this right."

The co-op will build the plant with an allocation from the Illinois General Assembly. Aquaculture is touted as a potential economic development boon to the state, and especially Southern Illinois, with its warmer climate and ample water surface in the area's ponds, lakes and water-filled strip pits.

Killian expects 40 to 60 jobs will be available at start-up, and peak at 100 positions. In the meantime, he's also hiring a processing plant and technical service manager to fill out the co-op's professional staff.

While most of the processing will proceed along an automated line to handle larger volumes of catfish or striped bass, the plant's capability to handle different species will rely on a manual line. This is where more exotic species, such as the tropical talapia, would be cleaned, cut and packaged for delivery.

The fish will be delivered live and temporarily stored in 30-foot-long tanks to ensure the freshest quality. Dead fish would be culled from the batches.

Primary target markets for the fish are St. Louis, which is the country's largest catfish consumer, and Chicago.

Besides processing, a disease diagnostic lab and area seminars will be headquartered out of the co-op building. Negotiations also are under way with an equipment developer to test prototype equipment at the plant.

There's also ample space within the 8-acre compound to build one or two demonstration ponds to show prospective farmers, high school students and others how aquaculture works.

While tanks will be filtered and special Environmental Protection Agency requirements will be met, disposing of water discharge may create a unique situation to build a wetlands behind the building, Killian said. Leftover parts from fish cleaning will be sold to pet food companies.

Pinckneyville Economic Development Director Tom Denton said the co-op's residence matches well with the building and surrounding industrial uses. The building is rented from MUMS through an open ended lease, Denton said. He declined to say how much rent is, except that it's reasonable.

AQUACULTURE OF TEXAS, INC.
4141 Fort Worth Highway
Weatherford, Texas 76087-8610
817-594-4872

To Whom it may concern:

Aquaculture of Texas, Inc. is a freshwater shrimp hatchery supplying **POST-LARVAE and JUVENILES** of Macrobrachium rosenbergii year round. Since 1986 our product has been shipped by air to domestic and foreign markets via Dallas/Fort Worth International Airport. Our state-of-the-art hatchery is located just 10 minutes west of Fort Worth; less than 50 minutes from the D/FW International Airport.

I have included a short list of books and periodicals which I think are indispensable to the shrimp grower. General information on pond construction and management can be found in numerous aquaculture books available in local public and college libraries. Also, your local county extension agent may be of additional assistance.

If you wish further information about our **POST-LARVAE or JUVENILES** for use in monoculture or polyculture ponds feel free to call me at **817-594-**4872.

Orders may be placed by phone or by Fax 817-732-8248.

Sincerely,

Craig Upstrom

Craig Upstrom
President

Aquaculture of Texas, Inc.

4141 Fort Worth Highway Weatherford, Texas 76087-8610
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COOPERATIVE EXTENSION SERVICE Mississippi State UNIVERSITY

FRESHWATER Prawns

Pond Production & Grow Out

A final phase of freshwater prawn (shrimp) production is grow out of juveniles to adults for market as a food product. Research in Mississippi has demonstrated this can be a profitable enterprise, and this publication provides guidelines for stocking and managing a freshwater prawn production pond.

Unless you have a hatchery/ nursery, you must purchase juveniles for the pond grow-out phase. There are commercial hatcheries in Texas, California, and Mexico that produce postlarvae and juveniles. The price is about $60 per 1,000 juveniles. You can minimize shipping costs if the hatcheries are located within a 10- to 14-hour driving distance of your grow-out facility.

Site Selection and Pond Design

Ponds used for raising freshwater prawns should have many of the same basic features of ponds used for the culture of channel catfish. A good supply of fresh water is important, and the soil must have excellent water-retention qualities. Well water of acceptable quality is the preferred water source for raising freshwater prawns. Runoff from rivers, streams, and reservoirs can be used, but quality and quantity can be highly variable and subject to uncontrollable change. The quality of the water source should be evaluated before any site is selected.

Locate ponds in areas that are not subject to periodic flooding. Before building ponds specifically for producing freshwater prawns, check the soil for the presence of pesticides. Prawns are sensitive to many of the pesticides used on row crops. Also, analyze the soil for the presence of residual pesticides. Do not use ponds that are subject to drift from agricultural sprays or to runoff water that might contain pesticides.

The surface area of grow-out ponds ideally should range from 1 to 5 acres. Larger ponds have been successfully used; ideally the pond should have a rectangular shape to facilitate distribution of feed across the entire surface area. The bottom of the pond should be completely smooth and free of any potential obstructions of seining. Ponds should have a minimum depth of 2 feet at the shallow end and a maximum depth of 3.5 to 5 feet at the deep end. The slope of the bottom should allow for rapid draining. You can obtain assistance in designing and laying out ponds by contacting a local office of the Natural Resources Conservation Service (formerly Soil Conservation Service).

Collect a soil sample from the pond bottom to determine whether lime is needed. Take soil samples from about six different places in each area of the pond, and mix them together to make a composite sample that is then air-dried. Put the sample in a soil sample box, available from your county Extension agent, and send it to the Extension Soil Testing Laboratory, Box 9610, Mississippi State, MS 39762, and request a lime requirement test for a pond. There is a charge of $3 per sample for this service.

If the pH of the soil is less than 6.5, you must add agricultural limestone to increase the pH to a minimum of 6.5, and preferably 6.8.

After filling the pond, fertilize the pond to provide an abundance of natural food organisms for the prawns and to shade out unwanted aquatic weeds. A liquid fertilizer, either a 10-34-0 or 13-38-0, gives the best results. Apply 1/2 to 1 gallon of 10-34-0 or 13-38-0 liquid fertilizer per surface acre to the pond at least 1 to 2 weeks before stocking juvenile prawns. If a phytoplankton bloom has not developed within a week, make a second application of the liquid fertilizer. Do not apply directly into the water because it is denser than water and will sink to the bottom; liquid fertilizer should be diluted with water 10:1 before application. It can be sprayed from the bank or applied from a boat outfitted for chemical application.

At least 1 or 2 days before stocking the juvenile prawns, check the pond for aquatic insect adults and larvae that might eat the juvenile prawns. You can control the insects by using a 2:1 mixture of motor oil and diesel fuel at the rate of 1 to 2 gallons per surface acre on a calm day. The oil film on the water kills the air-breathing insects and is more effective when applied on calm days.

If a water source other than well water is used, it is critically important to prevent fish, particularly members of the sunfish family (e.g., bass, bluegills, and green sunfish) from getting into the pond when it is filled. The effects of predation on freshwater prawns by these kinds of fish can be devastating. If there are fish in the pond, remove them before stocking prawns, using 1 quart of 5 percent liquid emulsifiable rotenone per acre-foot of water.

Stocking of Juveniles

Water in which postlarvae and juveniles are transported should be gradually replaced by the water in which they will be stocked. This acclimation procedure should not be attempted until the temperature difference between the transport and culture water is less than 6 to 10 °F. The temperature of the pond water at stocking should be at least 68 °F (20 °C) to avoid stress because of low temperatures. Juvenile prawns appear to be more susceptible than adults to low water temperatures.

Juveniles, preferably derived from size-graded populations ranging in weight 0.1 to 0.3 g, should be stocked at densities from 12,000 to 16,000 per acre. Lower stocking densities will yield larger prawns but lower total harvested poundage. The duration of the grow-out period depends on the water temperature of the ponds, and the time generally is 120 to 150 days in central Mississippi. Prawns could be grown year-round if you can find a water source that provides a sufficiently warm temperature for growth.

Feeding

Juvenile prawns stocked into grow-out ponds initially are able to obtain sufficient nutrition from natural pond organisms. At the recommended stocking densities, begin feeding when the average weight of the prawn is 5.0 g or greater. Commercially available sinking channel catfish feed (28 to 32 percent crude protein) is an effective feed at the recommended stocking densities. The feeding rate is based upon the mean weight of the population (Table 1). A feeding schedule has been developed by researchers at the Mississippi Agriculture and Forestry Experiment Station and is based upon three factors:

1. A feed conversion ratio of 2.5;
2. One percent mortality in the population per week; and
3. Mean individual weight determined from samples obtained every 3 weeks.

At the end of the grow-out season, survival may range from 60 to 85 percent, if you have practiced good water quality maintenance. Yields typically range from 600 to 1,200 pounds per acre. Weights of prawns range from 35 to 45 g (13 to 10 per pound).

Water Quality Management

Water quality is just as important in raising freshwater prawns as it is in raising catfish or any other species of aquatic animal. Dissolved oxygen (DO) is particularly important, and a good oxygen monitoring program is necessary to achieve maximum yields. You should routinely check and monitor levels of dissolved oxygen in the bottom one foot of water which the prawns occupy. Electronic oxygen meters are best for this purpose but are rather expensive and require careful maintenance to ensure good operating condition. The need for an electronic oxygen meter increases as the quantity of ponds to be managed increases. With only one or two small ponds, a chemical oxygen test kit is sufficient. Chemical oxygen tests kits that perform 100 tests are commercially available from several manufacturers.

Use a sampler for collecting samples from an appropriate water depth for dissolved oxygen analysis. These sampling devices are commercially available or can be fashioned. It is important the dissolved oxygen concentration in the bottom one foot of water does not fall below 3 parts per million (ppm). Dissolved oxygen concentrations of 3 ppm are stressful, and lower oxygen concentrations can be lethal. Chronically low levels of dissolved oxygen result in less than anticipated yields at the end of the growing season. Emergency aeration can be achieved by an aerator. The design and size of the aerator depend on the size and shape of the culture pond.

Oxygen depletions can be avoided. One method to predict low DO levels is to plot the level an hour after sunset and approximately 2 hours later. Plot these two readings on a piece of graph paper and connect them with a straight line (Figures 1 and 2). Oxygen consumption during the late evening and early morning proceeds at a constant rate, caused by the respiration of the animals and plants in the water. By extending the line from these two points over time you can quickly determine if the dawn DO concentration will decrease to a level that will stress or possibly kill the prawns. This method indicates whether emergency aeration is necessary and when to provide it.

Specific information on water quality requirements of freshwater prawns is limited. Although freshwater prawns have been successfully raised in soft water (5 to 7 ppm total hardness) in South Carolina, a softening of the shell was noticed. Hard water, 300-plus ppm, has been implicated in reduced growth and lime encrustations on freshwater prawns. Therefore, use of water with a hardness of 300-plus ppm is not recommended.

Nitrogen Compounds

Nitrites at concentrations of 1.8 ppm have caused problems in hatcheries but there is no definitive information as to the toxicity of nitrite to prawns in pond situations. High nitrate concentrations in ponds would not be expected given the anticipated biomass of prawns at harvest. High levels of un-ionized ammonia, above 0.1 ppm, in fish ponds can be detrimental. Concentrations of un-ionized ammonia as low as 0.26 ppm at a pH of 6.83 have been reported to kill 50 percent of the prawns in a population in 144 hours. Therefore, you must make every effort to prevent concentrations of 0.1 or higher ppm un-ionized ammonia.

pH

A high pH can cause mortality through direct pH toxicity, and indirectly because a higher percentage of the total ammonia in the water exists in the toxic, un-ionized form. For more information on ammonia in fish ponds, request **Extension Information Sheet 1333**. Although freshwater prawns have been raised in ponds with a pH range of 6.0 to 10.5 with no apparent adverse effects, it is best to avoid a pH below 6.5 or above 9.5, if possible. High pH values usually occur in waters with total alkalinity of 50 or less ppm and when a dense algae bloom is present. Before stocking, liming ponds that are built in acid soils can help minimize severe pH fluctuations.

Another way to manage to avoid any anticipated problems of high pH is to reduce the quantity of algae in the pond by periodic flushing (removing) the top 12 inches of surface water. Alternatively, organic matter, such as corn grain or rice bran, can be distributed over the surface area of the pond. This procedure must be accompanied by careful monitoring of oxygen levels, which may dramatically decrease due to decay processes.

In some cases, dense phytoplankton growth may occur in production ponds. To control algae, do a bioassay before using any herbicide in a freshwater prawn pond. To do a bioassay, remove a few prawns, put them in several plastic buckets containing some of the pond water, and treat them to see if the concentration of herbicide you plan to use is safe. Be sure there is adequate aeration, and observe the response of the prawns for at least 24 hours afterward.

Diseases

Diseases so far do not appear to be a significant problem in the production of freshwater prawns, but, as densities are increased to improve production, disease problems are bound to become more prevalent. One disease you may encounter is "blackspot" or "shell disease," which is caused by bacteria that break down the outer skeleton. Usually it follows physical damage and can be avoided by careful handling. At other times, algae or insect eggs may be present on the shell. This condition is not a disease, but rather an indication of slow growth, and is eliminated when the prawn molts.

Harvesting

At the end of the grow-out season, prawns may be seine or drain harvested. For seining, depth (or water volume) should be decreased by one-half before seining. Alternatively, ponds could be drained into an interior large rectangular borrow pit (ditch) where prawns are concentrated before seining. You can effectively drain harvest only if ponds have a smooth bottom and a slope that will insure rapid and complete draining. During the complete drain-down harvest procedure, prawns generally are collected on the outside of the pond levee as they travel through the drain pipe into a collecting device. To avoid stress and possible mortality, provide sufficient aeration to the water in the collection device.

Selective harvest of large prawns during a period of 4 to 6 weeks before final harvest is recommended to increase total production in the pond. Selective harvesting usually is performed with a 1- to 2-inch bar-mesh seine, allowing those that pass through the seine to remain in the pond and to continue to grow, while the larger prawns are removed. Selective harvest may also be accomplished with properly designed traps. Prawns can be trapped using an array of traditionally designed crawfish traps.

Table 1.
Weight-dependent feeding rates for semi-intensive pond grow out of *Macrobrachium rosenbergii*

Mean wet weight (g)	Daily feeding rate (% of body weight)[a]
<5	0
5 to 15	7
15 to 25	5
>25	3

[a] As-fed weight of diet / wet biomass of prawns x 100.

Figure 1.
Graphic method of predicting nighttime oxygen depletions in ponds. In this example it is predicted the oxygen concentration will drop to 2 ppm by 2:40 a.m., indicating emergency aeration should be started by 3:30 a.m.

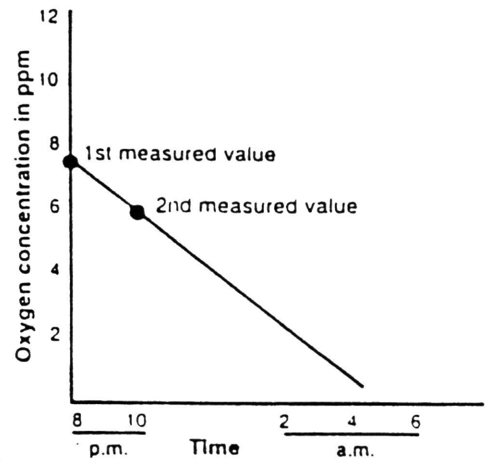

Figure 2.
Graphic method of predicting nighttime oxygen depletions in ponds. In this example it is predicted that no oxygen problem will develop in the pond during the night.

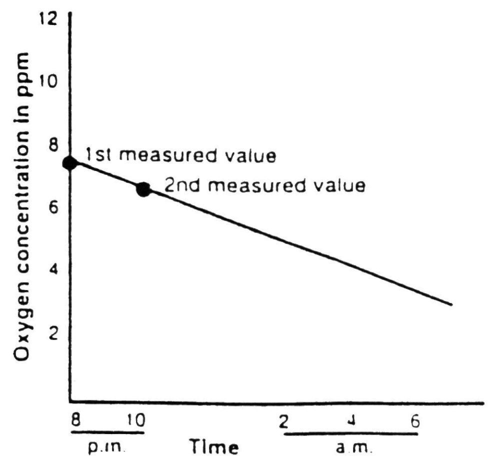

Figure 3.
A 24-month stocking and harvest scheme for intercropping freshwater prawns and crawfish. All years following year 2 will be the same as year 2.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Prawns	year 1					Stock				Harvest	Harvest		
	year 2					Stock				Harvest	Harvest		
Crawfish	year 1							■	Stock				
	year 2		Harvest	Harvest	Harvest	Harvest	Harvest	■	Stock				

Polyculture and Intercropping

Culture of freshwater prawns in combination with fingerling catfish has been successfully demonstrated under small-scale, experimental conditions, and appears possible under commercial conditions. Selective harvest can help to extend the duration of the availability of the fresh or live prawn product to the market. However, there is a lack of research to show whether selective harvesting or a complete bulk harvest is the most economical approach.

Before introduction of catfish fry, stock juvenile prawns at a rate of 3,000 to 5,000 per acre. Stock catfish fry at a density to insure that they will pass through a 1-inch-mesh seine used to harvest the prawns at the end of the growing season. Although polyculture of prawns and a mixed population of channel catfish has been successfully demonstrated, logistical problems arising from efficient separation of the two crops is inherent in this management practice. Moreover, when harvest of prawns is imminent due to cold water temperatures, catfish may not be a harvestable crop due to an "off flavor" characteristic. Polyculture of channel catfish and freshwater prawns may be best achieved through cage culture of the fish.

Recently, a scheme for intercropping of freshwater prawns and red swamp crawfish was developed and evaluated (Figure 3). Intercropping is the culture of two species that are stocked at different times of the year with little, if any, overlap of their growth and harvest seasons. Intercropping provides for a number of benefits that include:

1. Minimizing competition for resources;
2. Avoiding potential problems of species separation during or after harvest; and
3. Spreading fixed costs of a production unit (pond) throughout the calendar year.

Adult mature crawfish are stocked at a rate of 3,600 per acre in late June or early July. Juvenile prawns are stocked at a density of 16,000 per acre in late May and harvested from August through early October. In late February, seine harvest of the crawfish begins and continues through late June before stocking of new adult crawfish. Prawns are small enough to pass through the mesh of the seine used to harvest crawfish during the May-June overlap period.

Processing and Marketing

Production levels and harvesting practices should match marketing strategies. Without this approach, financial loss due to lack of adequate storage (holding) facilities or price change is inevitable. Marketing studies strongly suggest that a "heads off" product should be avoided and that a specific market niche for whole freshwater prawns needs to be identified and carefully developed.

To establish year-round distribution of this seasonal product, freezing, preferably individually quick frozen (IQF), would be an attractive form of processing. Block frozen is an alternative method of processing for long-term distribution. Recent research at the Mississippi Agriculture and Forestry Experiment Station suggests that adult freshwater prawns can be successfully live hauled for at least 24 hours, at a density of 0.5 pound per gallon, with little mortality and no observed effect on exterior quality of the product. Transport under these conditions requires good aeration. Distribution of prawns on "shelves" stacked vertically within the water column assists in avoiding mortality due to crowding and localized poor water quality. Use of holding water with a comparatively cool temperature (68 to 72°F) minimized incidence of water quality problems and injury by reducing the activity level of the prawns.

Economic Feasibility

Based on a current feed cost of $250 to $300 per ton, a seedstock cost of $60 per 1,000 juveniles, a 2.5 to 1 feed conversion, expected mean yields of 1,000 pounds per acre, and a pond bank selling price of $4.25 per pound, the expected net return is $2,000 to $2,500 per acre. Revenue and ultimate profitability depend on the type of market that is used. This estimated return does not include labor costs or other costs. Some thorough economic evaluations that incorporate annual ownership and operating costs under different scenarios for a synthesized firm of 43 acres, having 10.25 acres of water surface in production, are provided in Mississippi Agriculture and Forestry Experiment Station Bulletin 985.

By Dr. Louis R. D'Abramo, Professor, Dr. Martin Brunson, Extension Leader/Fisheries Specialist, and Dr. William H. Daniels, former Research Assistant, all with the Department of Wildlife and Fisheries.

Publication 2003

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GENERAL AQUACULTURE INFORMATION SOURCES

Partial Listing of Aquaculture Trade Magazines and Newsletters
Stuttgart National Aquaculture Research Center, USDA/ARS
Stuttgart, Arkansas 72160

NAME & ADDRESS	FORMAT	PUBLISHED
Aquaculture Magazine P. O. Box 2329 Asheville, NC 28802	Magazine	Bi-Monthly
Aquaculture Outlook ERS/USDA 1301 New York Avenue, NW Washington, DC 20005-4789	Report	Periodic
Arkansas Aquafarming U of AR Coop. Ext. Service P. O. Box 4912 Pine Bluff, AR 71611	Newsletter	Quarterly
Arid Lands Fish Production AZ Aquaculture Association College of Agriculture Shantz Bldg. 429 Tuscon, AZ 85721	Newsletter	Periodic
California Aquaculture Association P. O. Box 1004 Niland, CA 92257	Newsletter	Quarterly
Catfish Farmers of Arkansas 31 Linda Lane Vilonia, AR 72173	Newsletter	Periodic to members
Catfish Journal P. O. Box 55648 Jackson, MS 39296	Newspaper	Monthly
Farm Pond Harvest 1390 North 14500 East Road Momence, IL 60954	Magazine	Quarterly
Fish Farming News P.O. Box 37 Stonington, ME 04681	Newspaper	Bi-Monthly
FOR FISH FARMERS MS Coop. Ext. Service P. O. Box 142 Stoneville, MS 38776	Newsletter	Periodic

Kentucky Aquaculture Newsletter KY State Univ.Coop. Ext. Service Frankfort, KY 40601	Newsletter	Periodic
Missouri Aquaculture P. O. Box 630 Jefferson City, MO 65102-6864	Newsletter	Periodic
National Aquaculture Association 111 W. Washington Street, Ste.1 Charles Town, WV 25414-1529	Newsletter	Periodic to members
Southeast Aquaculture News NC Coop. Ext. Service Pitt. Co. Office, 403 Govt. Circle Greenville, NC 27834	Newsletter	Periodic
Salmonid 111 W. Washington Street, Ste.1 Charles Town, WV 25414-1529	Magazine	Quarterly
World Aquaculture 143 JM Parker Coliseum, LSU Baton Rouge, LA 70803	Magazine	Quarterly

Cooperative Fisheries
Research Laboratory
SOUTHERN ILLINOIS UNIVERSITY AT CARBONDALE

ILLINOIS AQUACULTURE RESEARCH AND DEMONSTRATION CENTER
SIUC Fisheries Bulletin No. 11
June 1992

Dan Selock
Aquaculture Technology Transfer Specialist
And
Roy Heidinger
Director

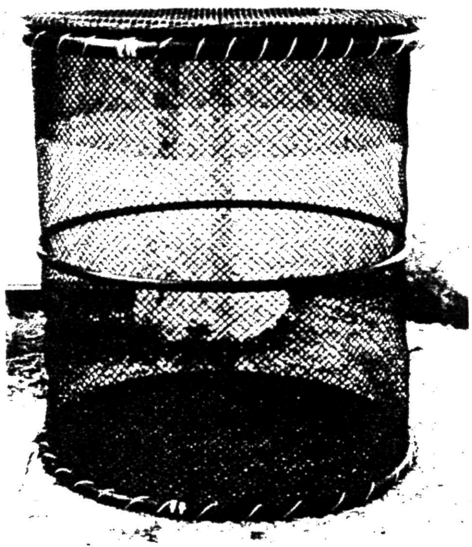
CAGE CULTURE IN ILLINOIS: SOME PROS AND CONS

INTRODUCTION

Many existing bodies of water in Illinois have the potential for multiple use. They may be used for livestock watering, irrigation, recreational fishing, swimming, and, in some cases, aquaculture - the cultivation and marketing of aquatic animals and plants.

Aquatic animals and plants can be raised for personal use and consumption or for supplemental farm income. Usually the open pond method of aquaculture is practiced, but, under certain circumstances, raising fish in floating cages is an alternative to open pond culture. Cage culture can utilize an existing body of water by enclosing the fish in a cage or basket which allows water to pass freely between the fish and the pond.

Open pond culture is the most practical method of aquaculture in Illinois at this time. Raceways require vast quantities of water to flush the fish waste material from the rearing tank, and tank culture requires a great deal of set-up cost and knowledge.



A round fish cage can hold up to 400# of catfish.

Room 173B Life Science II • Southern Illinois University at Carbondale • Carbondale, IL 62901
Tel 618-536-7761 • Fax 618-536-7761

On the other hand, a common problem with open pond culture in many existing bodies of water is the inability to drain and/or seine the pond or lake. Ponds that are deep, irregular in shape, uneven on the bottom, cluttered with trash or stumps, or have no suitable drains or water supplies do not lend themselves to efficient seining. Floating fish cages thus allow some existing ponds to be used with a relatively low investment. However, there is no practical reason to use floating cages in ponds that are drainable and/or seinable, except to sort, grade, or separate different species of fish. Generally, fish experience less stress in an open pond than in a cage, therefore, some degree of risk is taken with cage culture.

The history of cage culture easily goes back to the end of the last century when aquaculturists produced fish in Southeast Asia, using wood or bamboo cages and trash or food scraps as food for the fish. Modern cage culture originated in the 1950's when synthetic materials for cage construction were developed. Research for improving cage culture has been restrained due to the better economy of open pond culture. Currently, increasing consumption of fish, declining wild fish stocks, a desire to reclaim surface-mined property, and a poor farm economy have produced new interest in cage culture. Alternative farming techniques (those other than traditional agricultural crops and animals) are being developed today, and aquaculture is one of the fastest growing areas. Cage culture may allow a small or limited resource farmer to rent or lease existing water and supplement their income.

SOME PROS

The prospective aquaculturist must determine if cage culture is feasible for them in their particular situation. This production method, as with any other, has advantages and disadvantages. A thorough consideration of all aspects should be made. The advantages of cage culture are:

1. Different types of water resources can be used, such as lakes, farm ponds, surface-mining final cuts, quarry pits, borrow pits, and irrigation canals. Several of these are existing water resources, therefore, construction costs are less for the facility. Many of these may also be rented or leased from year to year which would enable the fish farmer to expand his operation accordingly. The use of public waters for aquaculture in Illinois is not encouraged at this time.

2. Cage culture does not usually adversely affect the management of a pond for sport fishery purposes. It sometimes enhances the sport fishery through increased fertilization.

3. The initial investment is relatively low if an existing body of water is used.

4. The feeding activity and health of caged fish can be observed, and the fish can be accurately sampled.

5. Treatment for disease (dip or medicated feed) can be accomplished for a specific group of fish at a time instead of treating the entire pond.

6. The fish crop can be harvested by removing the cage from the water or portions of the crop by dipping a few at a time. As the faster growing fish reach market size, they can be removed to allow the smaller fish access to the food. The equipment needed to harvest a cage is less costly than that used in open pond culture.

7. Losses to bird and animal predation is reduced.

SOME CONS

The advantages of cage culture are impressive, however, the level of risk taken, when compared to open pond method, is higher. The amount of fish (pounds per acre) that can be reared in a pond can not be increased by the use of cages, especially in ponds with wild fish populations. Some of the disadvantages of cage culture are:

1. Floating cages can be expensive if purchased rather than constructed on the farm or if rust resistant coated wire is used to deter turtles and muskrats.

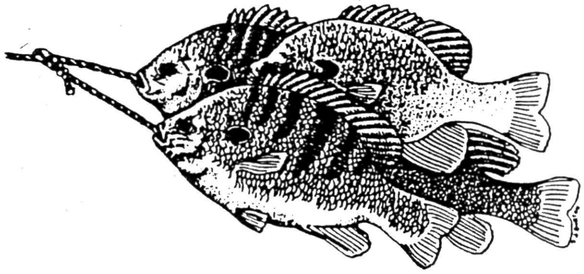
2. The nutritionally complete floating feed which must be used is more expensive than the diets used in open pond culture.

3. Since the fish are crowded into a relatively small space that usually is not moved around the pond, poor water quality within the cage can occur more often than outside the cage. Uneaten food and fish wastes may accumulate directly below the cage. The biological oxygen demand (BOD) to decompose this material and the resulting fertilization in the local area can result in algal blooms which would deplete dissolved oxygen at night and on cloudy days.

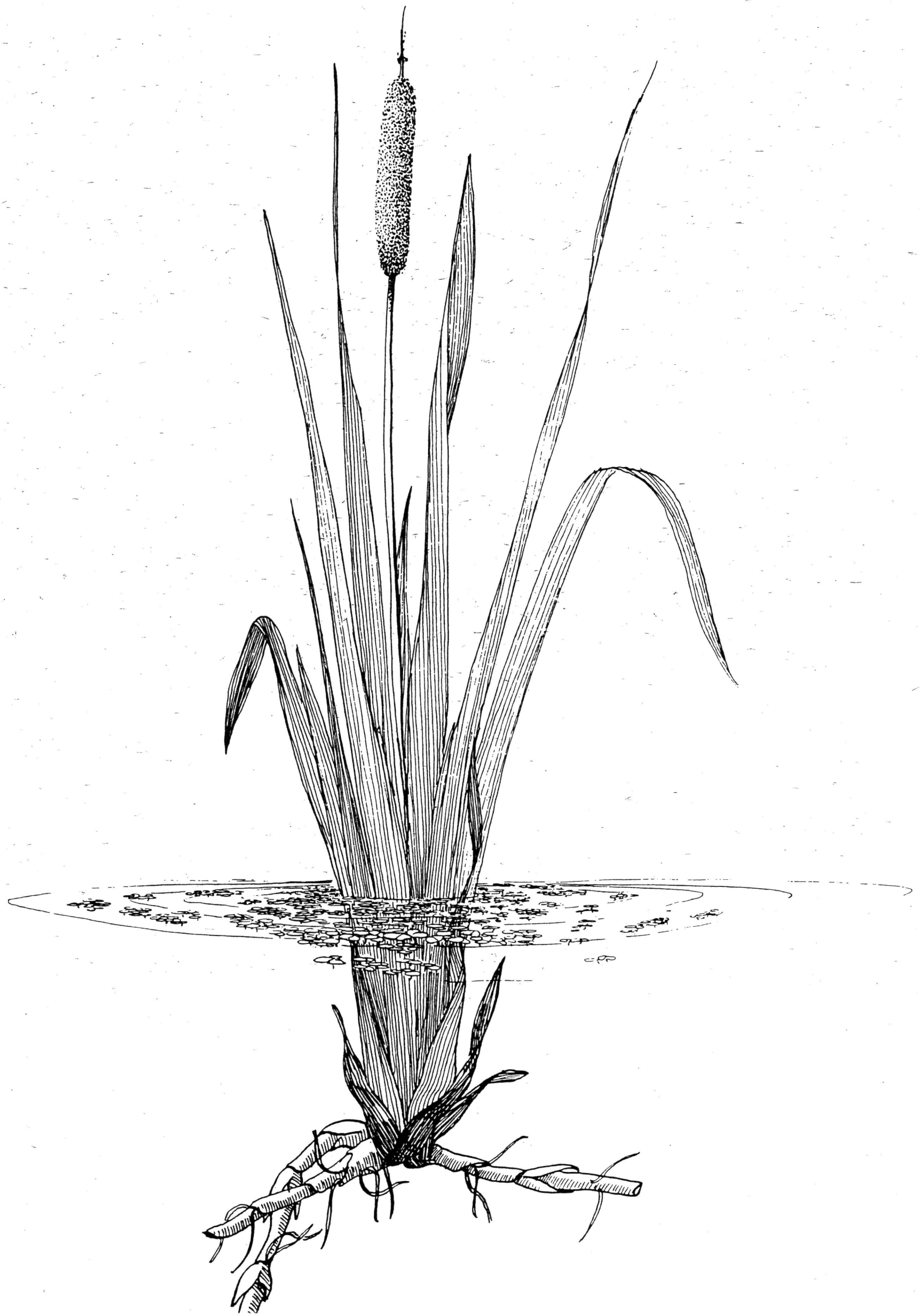
4. Vandalism or theft can occur when cages are used. It is best to locate cages where they can be observed on a regular basis or to own a large dog.

5. Fish health can be a problem with cages due to the crowding. Parasitic and/or bacterial outbreaks can affect the entire cage in a short amount of time.

The potential for failure with cage culture due to the disadvantages should not be taken lightly. On the other hand, if nutrition, water quality, and fish health are managed properly, some of the risk can be removed.



Acknowledgement: This bulletin was supported in part by a grant from the Illinois Department of Commerce and Community Affairs.



Cooperative Fisheries
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ILLINOIS AQUACULTURE RESEARCH AND DEMONSTRATION CENTER
SIUC Fisheries Bulletin No. 13
June 1992

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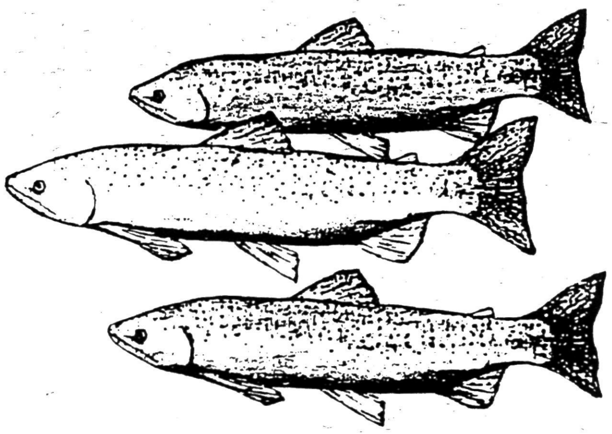
Roy Heidinger
Director

CAGE CULTURE OF RAINBOW TROUT IN ILLINOIS

INTRODUCTION



Aquaculture in Illinois is the rearing of aquatic animals and plants for personal use and consumption or for supplemental farm income. Usually the open pond method is practiced, but, under certain circumstances, such as the inability to drain and seine the pond, floating fish cages can be used. Cage culture of fish can make use of an existing body of water by enclosing the fish in a cage or basket which allows the water to pass freely between the fish and the pond.

The warm months of May through October in Illinois are suitable for the cage culture of channel catfish. Several aquaculturists are raising catfish in cages throughout Illinois. However, little to no growth of catfish takes place in the cages from November to May. The fish are generally overwintered with moderate success. As an alternative, a cold water fish, such as rainbow trout, could be raised during the late fall, winter, and early spring - 150 to 175 days. Trout cannot survive when the water temperature is above 70 degrees F. for an extended period of time, but do well in colder water. Other states have proven that trout grow well in cages. They adapt to crowded conditions and eat a processed feed designed to meet their dietary requirements.

A double cropping cage system of channel catfish and rainbow trout could increase the economic potential of fish culture by allowing double use of the pond, cages, docks, and other equipment.

SITE SELECTION

The success or failure of cage culture often depends upon proper site selection. Certain pond characteristics are necessary if some of the risks involved in cage culture are to be reduced or eliminated. Most of these criteria focus upon maintaining adequate water quality inside the cage.

Sufficient water must be in the pond throughout the year. At least one to two feet of water are required between the bottom of the cage and the pond bottom at all times so that fish wastes and excess feed can be flushed away from the cage. Small ponds cannot breakdown large amounts of fish wastes fast enough to avoid water quality problems. Larger ponds have a greater capacity to buffer the effects of wastes and feed residues. They also tend to be deep enough to reduce aquatic plant problems. Ponds that are at least one surface acre and six to eight feet deep work well for both catfish and trout production.

Ponds used for cage culture should not be located in areas where surface water run-off from adjacent land could contaminate them. Certain toxic or nutrient rich compounds can be harmful to the fish and people that eat them.

The direction of prevailing winds and how they strike a pond are important site selection characteristics. Wind generally is the most important component in pond water mixing. Therefore, cages should be placed in those ponds that can maximize the water movement generated by a southwest wind. Ponds low in a valley or deep in the woods usually will not have good water circulation.

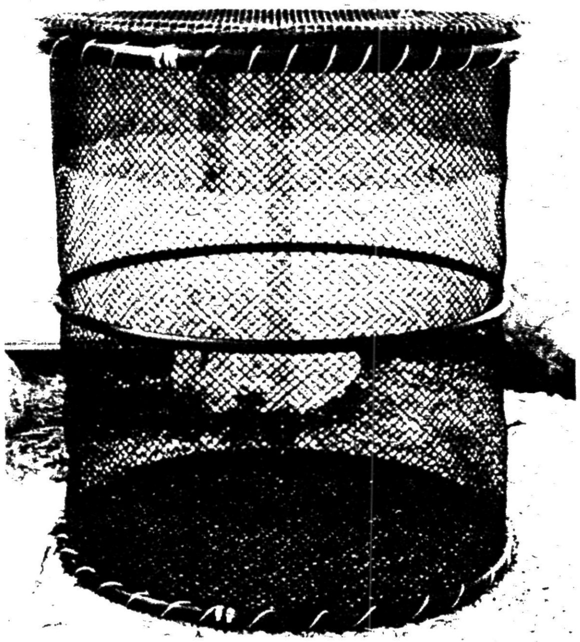
Finally, access to double crop ponds year around is important. Fish require regular feeding, whether it is raining in the spring and summer or snowing in the winter. Also, harvest of the fish should be planned around timely marketing and not the weather.

The "T" shape keeps a floating dock steadier.

CAGE CONSTRUCTION

Floating fish cages can be constructed in several shapes and from a variety of materials. The most popular cage design for the culture of channel catfish and rainbow trout is a cylinder. It has no corners for the fish to run into and become injured; and, when constructed of plastic materials, they are light enough for one person to pull partially out of the water to crowd the fish for harvest.

The netting material used for the body of the cage must allow maximum water circulation through the cage without the possibility of fish escapement. Mesh sizes less than 1/2 inch often clog with algae. Netting material of 1/2 and 3/4 inch mesh are most commonly used. A detailed manual on fish cage construction is available from the Aquaculture Specialist at Southern Illinois University.



A cylinder cage can be constructed inexpensively.

STOCKING

Rainbow trout can be grown in cages from a medium sized fingerling to a harvestable fish in 150 to 175 days. The fingerling size stocked greatly affects the harvest size obtained. Suppliers of rainbow trout fingerlings are in western Kentucky and Wisconsin. Be sure to inquire about a Salmonid Import Permit from the Illinois Department of Conservation (IDOC) before importing or possessing trout in Illinois. The IDOC requires that salmonids brought into the State come from hatcheries certified as free of certain diseases.

Stocking can take place after the water temperature has cooled and remains below 70 degrees F. Three hundred trout fingerlings six to eight inches in length should be stocked per 40 cubic feet cage if 1/2 to 3/4 pound fish are desired at the time of harvest. Larger fish at harvest would require eight to ten inch fingerlings stocked.

A maximum production estimate of four cages, or about 1,000 pounds, per surface acre is a conservative way to start and learn how to raise trout. Higher production levels may be achieved with experience.

HANDLING AND HAULING

Rainbow trout require more care in handling and hauling than do channel catfish. Plan ahead to avoid stressful situations, transfer the trout in water from the truck to the cage as much as possible, and aerate.

FEED AND FEEDING

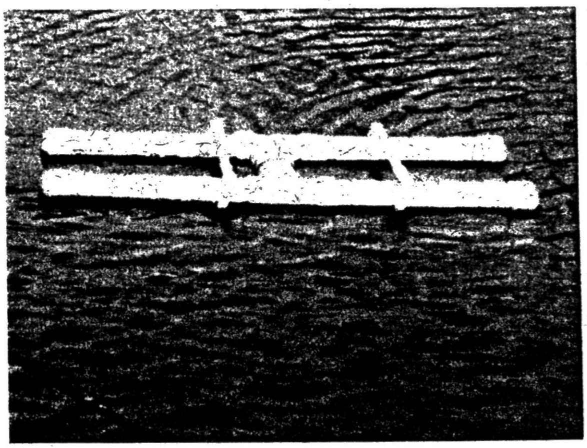
Rainbow trout demand a higher quality feed than channel catfish. Nutritionally complete trout feed is available, and a level of 36 to 38% protein is required for cage culture. Trout feed is more expensive than channel catfish feed, but it is highly recommended for success.

Floating feed is preferred over sinking feed since the amount consumed can be determined much better. Trout will feed less in the mid-winter months if the water temperature is less than 40 degrees F. It may be necessary to reduce the ration to prevent wasting feed. Late afternoon is the best time to feed trout during cold weather.

Some growers sample and weigh fish from each cage every month. The rate of feeding, from 2 to 5% of the body weight per day, may be determined from the sample sizes. A simpler method and one that does not stress the fish is to feed all that the trout will consume in 10 minutes during the warmer temperatures and 30 minutes for the colder temperatures. As the fish grow, you will need to change the size of the feed pellet. For fingerlings 3 to 6 inches, a 1/8 inch pellet will be sufficient. From 6 inches until harvest, you may use 5/32 or 3/16 inch pellets. Medicated feed may be necessary if fish become diseased. Only approved medications may be used.

DISEASE AND WATER QUALITY

Disease is usually not a problem unless the fish are stressed in some way. The greatest danger in winter production of trout is "winter kill" which is really oxygen depletion under the ice. When ice freezes solid on the surface of the pond and snow accumulates on the ice, very little light can penetrate into the water, and photosynthesis is reduced. Photosynthesis is the only mechanism by which oxygen is supplied to the ponds under the ice.



Diffusers suspended about six feet deep mix the water.

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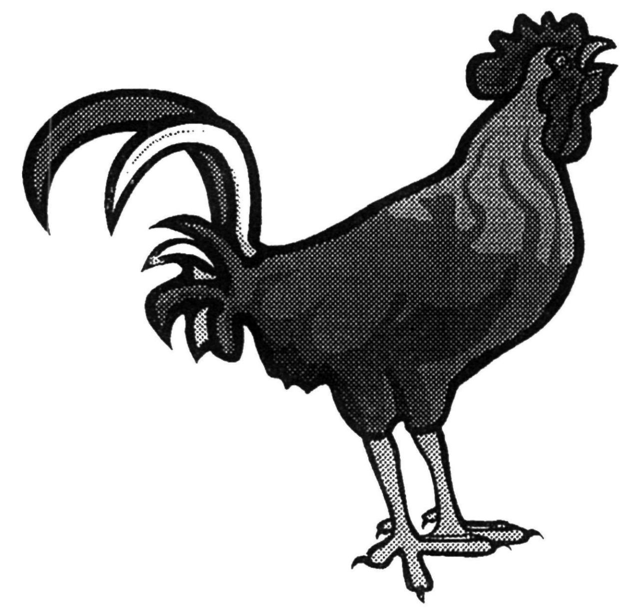
Free-Range Poultry



Free-Range Poultry

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ATTRA
Appropriate Technology Transfer for Rural Areas

SUSTAINABLE CHICKEN PRODUCTION

LIVESTOCK PRODUCTION GUIDE

ATTRA is the national sustainable agriculture information center funded by the USDA's Rural Business -- Cooperative Service.

Contents:

Introduction

Selling "farm-fresh" chicken and eggs is a marketing opportunity for enterprising farmers. These farmers raise chickens on outdoor range or in existing farm buildings to keep overhead costs low. Little or no medication is used in the feed. Market potential exists for products from poultry raised in what consumers consider to be "natural" environments.

Per-capita consumption of poultry products has climbed dramatically as large integrators have made poultry among the "best buys" at the supermarket. Each U.S. citizen ate an average of 97 lbs. of poultry and 234 eggs in 1993 (1). However, many consumers are also interested in homegrown poultry. Some consumers consider homegrown poultry more "natural" than industry-raised poultry; others want to support family farms and locally produced goods.

In the industry, usually large, loose-litter houses are used for broiler production. Layers are usually kept in small cages with 3 to 4 birds in each. In "sustainable poultry production," alternatives to confinement housing and cages are considered, such as access to range. Preventative management to maintain health is emphasized instead of routine medication. Nonconventional processing and marketing channels may be explored as part of alternative production. Poultry production can be a low-capital farm diversification strategy. Sustainable agriculture stresses environmentally sound and economically viable approaches to agriculture, and focuses on low-input strategies and support of rural communities by maintaining the family farm.

A common feature of alternative production models includes access to range. Access to range can help reduce feed costs, reduce stress compared to confinement, and provide a marketing advantage for certain market segments. An alternative poultry production strategy can reduce health problems and eliminate routine medication. This adds to the marketing advantage since some consumers want birds raised with no pharmaceuticals in the diet. Poultry manure can add fertility to the pasture and the manure is spread directly onto the field, eliminating waste disposal problems. Many pasture-based systems are seasonal—young birds need to be fully feathered before putting them out on pasture. These systems tend to be low cost and require little capital for start-up. Pasture-based systems are widely used in Europe on a large scale.

The focus of this publication is alternative chicken production. General information on small-scale poultry production is already available from many sources such as books, magazines, and Extension publications. Information on general topics—such as setting hens, brooding, culling, etc.—can be obtained from these sources. Some small-scale chicken books listed at the end of this publication in the Resources Section.

This publication is part of a series on sustainable chicken production. Please also see the ATTRA publications Sustainable Egg Production, Feeding Chickens, Processing and Marketing Chicken Products: Meat and Eggs.

Alternative Production Methods

The terms for alternative poultry operations are loosely defined in the U.S. Countries in the European Community (EC) have specific criteria defined by EC trading standards regulations in order to label eggs as free range, semi-intensive, deep litter, perchery, etc. (2); however, for the purposes of this publication, the following operations are described:

- free-range
- pastured poultry
- semi-intensive
- "yard and coop"
- innovative

Most of these models feature access to pasture but with modifications. Simply turning the chickens loose to run free on the farm may be fine for a family flock, but not to produce poultry commercially.

Free-range

"Free-range" refers to operations using moveable housing and access to pasture. In free-range operations, portable houses or pens are moved regularly so that chickens may forage grass, seeds, and insects. Maximum stocking density should be 200 birds per acre (3).

Some free-range operations have automatic watering systems in the field and specially constructed feeders to protect feed from the weather. The pasture area may be tightly fenced to keep predators from entering; portable housing provides safety at night.

Ohio farmer Herman Beck-Chenoweth (4) uses a free-range model to produce broilers. Long portable houses (skids), which hold up to 400 broilers each, are towed by tractor every few weeks to new locations in the pasture. The wooden skids are enclosed with chicken wire with litter-covered floors, tarp-covered gable roofs, and doors on both ends. Concentrate feed costs are reduced by access to range. He uses Cornish cross broilers and finds that they range about 100 feet away from the skids. The only fencing required is a strong perimeter fence to keep out neighbors' dogs. Predation at night is not a problem if the chicken wire is tightly attached to the skid; during the day, the birds run back to the skid if threatened. Since the birds are never confined, except at night for safety, this model appeals to those interested in animal welfare issues. In order to use this free-range model, you need a tractor, draft horse, or a strong pick-up to move the skid. Beck-Chenoweth's model is described in great detail in his book Free-Range Chicken Production and Marketing (4). He also edits a newsletter called the Free-Range Forum.

There are many modifications of free-range, especially "protected free-range," such as field pens that are regularly moved to fresh pasture. One that has received a lot of attention is "the pastured poultry model" (discussed below). There are also many models of free-range egg production, such as the "eggmobile," discussed in the ATTRA publication Sustainable Egg Production.

Pastured poultry

"Pastured poultry" is a term used to describe a modification of free-range—a field pen where the grazing area and bird density is strictly controlled. Joel Salatin (5) has developed this innovative model in which broilers are pastured in floorless pens, which are moved daily to fresh pasture. Seventy-five to one hundred chicks (two to four weeks old) are placed in 10' x 12' x 2' pens. The pens follow a cattle rotation. Feed concentrate is provided in the pen, along with water. In this system, allowing the birds to forage on plants, seeds, insects, and worms reduces concentrate feed costs by 30%.

Salatin raises 8,000 birds a year from March to October. Death losses at the Salatin farm average less than five percent, with mortality under two percent in some flocks. Bird performance is good—reaching slaughter size by eight weeks with a carcass weight of 4 to 4½ pounds.

The cages are moved by hand by putting a specially designed dolly on one end and lifting the pen with a handle on the other end. The pens, weighing about 200 lbs., can be dragged in this way. The pasture needs to be kept short (about 4-8 inches). Further issues about pasture usage and feeding is available in the ATTRA publication Feeding Chickens.

Several producers have modified the cage design by constructing it with PVC pipe, instead of wood, to lighten it. Some producers have installed a gabled tarp roof tarp to allow more heat to escape.

Salatin's pastured poultry model is described in great detail in his popular 330-page book, Pastured Poultry Profits (6). This publication includes information on brooding, pen construction, feeding, pasture management, processing, and marketing. The book and a video can be ordered from The Stockman Grass Farmer (7).

In response to growing interest about the pastured poultry model, an organization called the American Pastured Poultry Producers Association (APPPA) (8)was formed in 1996. APPPA was formed to help producers network for information, used processing equipment, etc. Membership costs $20 per year and includes a subscription to the newsletter Grit! The newsletter editor is Diane Kaufman (8), a longtime pastured poultry producer—contact Kaufman for more information on APPPA and to join.

Heifer Project International (HPI) (9), an Arkansas development organization is sponsoring a project to integrate pastured poultry onto the farms of limited resource farmers in the South. (Case studies from this project will be available from ATTRA in 1999.) Skip Polson at HPI coordinates the project and is also a pastured poultry producer.

The pastured poultry model has also been adapted for egg production as described in the ATTRA publication Sustainable Egg Production.

Semi-intensive:

"Semi-intensive" refers to permanent housing with access provided to a yard or pasture. According to an article from World Poultry Science Journal (3), chickens in semi-intensive operations are raised in non-moveable buildings with access to outdoor grazing in pens that are used in rotation. Feed and water are provided within the houses; stocking density is up to 500 birds per acre.

The chickens should be rotated through different pens; otherwise, a classic dirt chicken yard can result. Vegetation may disappear, because chickens are rough on plants and too much hot manure is deposited. Medicated feed may be needed to control disease in an overcrowded chicken yard, but rotating the chickens to fresh ground helps prevent disease.

Entrepreneur David Wilson (10) led an effort in this decade to establish semi-intensive broiler production on a commercial level in the U.S. Based in Kentucky, Wilson used contracted growers with older chicken houses, some built in the 50's, on their farms. The flocks were generally no larger than 6000 birds—actual flock size depended on the square footage of the particular house. Stocking density was 1 square foot per bird in the houses (industry averages are about 0.5 to 0.7 square feet) and 22 square feet per bird on the range. Wilson believes an ideal set-up would be 4500 birds in a 4500 square foot house.

The total range space was usually a couple of acres around the house. According to a former production manager, John Purdy (11), it was problematic setting out the range area since the houses were built without regard to range. Wilson believes an ideal would be to have at least two ranges in order to rotate. If the house is oriented east-west, then it would be possible to have north and south ranges. Wilson did not have the opportunity to improve the range, but he believes that with legume plantings, ranges could provide a substantial portion of the broilers' diet.

The broiler operation was year-round, but the birds did not go outdoors when the temperature dropped below 40°F, making a 90-day window in Kentucky in which the birds stayed indoors. During this time, stocking density was reduced and alfalfa was added to the feed. The birds were allowed to range at 4 weeks of age during the summer and 5 weeks during the fall.

There was a low incidence of parasites, even though parasiticides were not included in the diet. Wilson speculates that since it was a closed system and biosecurity was high, parasites never got established. Disease was not a problem.

Purdy speculated that if a producer used conventional Cornish cross birds in this production model, the birds could possibly be reluctant to range outside—young birds are especially tentative. However, raising the birds in a house with a high level of natural lighting and using a small house with multiple exits may encourage young Cornish cross birds to venture outside. If they are still reluctant to leave the house, placing a range feeder outside may encourage them. Another alternative is to use breeds that are more conducive to foraging; however, the market conformation of the breed is important since most consumers expect birds to have plump breasts.

"Yard and coop"

"Yard and coop" is a catch-all term referring to poultry operations that do not include a formal plan for rotating pasture or have no pasture access at all. Some producers let chickens, mainly layers, roam the farm at will, shutting them up at night to protect against predators. While this is a low-input system, disadvantages include loss to predators and droppings in undesired places. It is generally not practical for commercial production.

Many producers raise chickens in the familiar chicken coop. Much literature is available on chicken coops. The magazine Countryside & Small Stock Journal publishes many articles on this topic; a useful book is the Homesteader's Handbook to Raising Small Livestock (see Resources Section). For more information on general small-scale chicken housing and equipment such as nestboxes, waterers, roosts, etc., refer to books and other materials that are listed in the Resources Section.

Some producers use unusual housing for small flocks such as hoophouses, where a loose-litter system is employed. The second edition of the book Chicken Tractor (12) describes how to build a straw bale house as winter protection for layers. There has been continued interest in incorporating poultry into greenhouses.

In Europe, open-ended houses with covered straw yards for layers as an intermediate system between wholly outdoor and wholly indoor.

Deep litter houses are more fully enclosed. Other enclosed models include aviaries and percheries.

Innovative

The "chicken tractor," developed by Andy Lee, is designed to be integrated with vegetable production. It is a floorless pen, usually 4'x10', enclosed with chicken wire and a covered top as protection against the weather. Twenty broilers are kept in this size pen. The pen is moved daily on fallow beds. You may need twice the garden space to use this system, but this allows the land to be "treated" every other year. Your land will become very fertile—doubling garden yields or better. The chickens weed, till, and fertilize the beds. They also help in insect control. In addition to a concentrate ration, kitchen and garden wastes are thrown in the pens as feed.

There are several different ways the chicken tractor is used in a garden. The pen is rotated daily to a fresh spot as described above. Or the pen can stay stationary, and fresh straw bedding is added daily to create a raised garden bed. This is especially useful in areas with poor soil. Or something in between these two systems: the pen stays on the garden bed longer than one day, but less than one month. This puts a sheet-mulch on top of the beds to kill grass and weeds and add fertility. Andy Lee's book Chicken Tractor (12) provides detailed information.

There are also various permaculture models for range chicken production— permaculture integrates natural systems with human needs for food, shelter, fiber, etc. An example is a system in which a central chicken house has doors (popholes) to provide access to four different yards. Chickens have access to a single quarter for 2 months. When the chickens finish tilling and weeding one of the yards (a quarter), they are excluded from the quarter. The quarter can then be planted to high-value crops like vegetables and flowers, followed by forage crops (rye, buckwheat, alfalfa. etc.) that the birds will eat when they move back to the quarter in 6 months (13) Bill Mollison's book Permaculture: A Designer's Manual (14) offers further permaculture designs for poultry. Contact ATTRA for more information on the use of chickens in permaculture systems

A "composting chicken house" provides an alternative for manure management in buildings where manure and litter accumulate. About six inches of dry material, such as sawdust or straw, is spread on the dirt floor of the poultry house and sprayed with compost starter. Scratching by the birds helps mix the dry material and the chicken manure—these products then begin to decompose, eventually becoming compost. The compost is periodically rototilled to keep a crust from forming. Additional litter or water may be added if the mixture becomes too wet or dry. A side benefit is that the composting process stabilizes the floor temperature at about 70°, keeping the birds more comfortable in winter and summer. Litter compost is removed from the house periodically to be used as fertilizer or sold. Composting chicken houses are described in a late-80's publication called Down on the Farm . This inexpensive publication describes the composting chicken house operated by Natural Foods Associates (15).

Breeds for pasture-based production

Light, heavy and dual-purpose chickens have been bred to suit different production goals. The light breeds lay large quantities of eggs and are generally nervous birds which are not inclined to become "broody." The heavy breeds and their crosses are used for meat production, primarily broilers. Rhode Island Reds and Whites and Barred Plymouth Rocks are dual-purpose breeds—large birds that produce eggs as well as meaty broilers. They are useful for small flocks.

Pastured poultry producer Joel Salatin (5) recommends choosing a meat type that consumers are accustomed to, such as the industry type, Cornish cross. Although this breed is not an aggressive forager, it is a fast-grower. Other breeds may have less meaty breasts. It is important to find a supplier that you are happy with. Some hatcheries have their own breeding flocks; others buy eggs from other hatcheries.

Entrepreneur David Wilson's (10) emphasis in pasture-based production was culinary. He wanted to produce a differentiated chicken product—a chicken with an exceptional taste. He was introduced to French chicken by European-trained chefs and he imported the La Belle Rouge™, which is a trademark for breeds accepted into a French program that promoted range production. Since the birds are typically harvested at about 9 to 11 weeks, the slower growout may also contribute to flavorfulness.

The American Livestock Breeds Conservancy (16) can recommend endangered poultry breeds that need protection. An important part of sustainability is maintaining a wide genetic base.

Feeding Options

For information on feeding, home-mixed rations, certified organic diets, feeding concerns for pastured birds, please see the ATTRA publication Feeding Chickens.

Flock Health in Alternative Poultry Production

Chickens in the past used to be range-raised. However, commercial poultry houses may have large amounts of fecal dust and ammonia in the air, and bird density may be high (25,000 birds in a building 40' x 400'). These conditions require routine medication such as antibiotics. Public concern exists about the routine use of antibiotics in livestock production and the perceived risk of transfer to humans of strains of bacteria resistant to antibiotics. Concern about possible residues in meat and eggs also contributes to consumer interest in poultry raised with a minimum of medication. The following sections discuss health concerns for both indoor and outdoor flocks, with details on the special health concerns for outdoor flocks.

Sanitation and isolation

Sanitation and isolation are preventative measures to control disease problems. The "all-in, all-out" approach is a useful way to maintain flock health in confined flocks. Under this method, each batch of birds is treated as a unit from the time it arrives on the farm until departure. Facilities are thoroughly cleaned and disinfected between batches of birds. Producers not using the "all-in, all-out" approach should quarantine new birds for two weeks or more to make sure they are not bringing in diseases. However, in general it is a good policy not to add new birds to an old flock. Human visitors may introduce diseases if they have been around other flocks. Borrowed poultry equipment, rodents, and poultry shows can be further sources of disease. Sick or dead poultry should be removed promptly. Mixing different species of poultry can spread infections. A disease may not affect one type of poultry and therefore be hidden, but it may be devastating to another species. An example is blackhead, which can be spread from chickens to turkeys.

In contrast to the "all-in, all-out" approach which includes thorough sanitation between batches, some small-scale producers believe that disinfection not only kills pathogens but also beneficial microbes. For example, some producers do not clean facilities between brooder batches because they believe the bedding helps new chicks build defenses against diseases they will eventually encounter, such as coccidiosis.

Vaccination

Vaccination may be done by the hatchery, but chicks can also be bought unvaccinated. It is recommended to vaccinate for Marek's disease as a rule of thumb, and consider vaccination programs, particularly for layers, since they are kept longer than broilers (17). Producers should be aware of the risks of not vaccinating—if a disease outbreak occurs, it may be necessary to get rid of the whole flock. If there are a lot of neighboring flocks in an area, it is especially important that disease control be effective, so that diseases do not spread. It may be wise to consult with a local veterinarian or Extension personnel about the importance of vaccinations.

Alternative treatments

Some "natural products" like diatomaceous earth (DE) have been used for control of external and sometimes internal parasites in livestock, including chickens. DE is the fossilized remains of diatoms, tiny sea organisms, which have microscopic cutting edges that may pierce the outer protective layers of insects and parasites, causing them to die by dehydration. Some producers believe DE is effective, based on their experiences; however, its efficacy has not been documented by research. Cedar chips, tobacco, petroleum oil, and brewer's yeast have also been used to control external parasites such as lice.

Homeopathic treatments in chickens have been used as an alternative to antibiotics in Germany and have been particularly treating respiratory diseases and diarrhea (18). A U.S. referral service, the American Holistic Veterinary Medical Association (19), may be a source of further information on alternative treatments. Some producers believe that probiotics are useful in preventing disease in poultry. Probiotics are live microbial feed supplements that may improve livestock health by "feeding" beneficial gut microbes.

Poultry books and the Extension service are useful in poultry disease identification, treatment, and preventative care. Gail Damerow's The Chicken Health Handbook (20) is a very practical resource guide for small-scale producers. It is written for non-vets and includes sections on chicken health, parasites, diseases, diagnosis, and postmortem.

Special Health Concerns for Pasture-based birds

Stress plays a role in the bird's immune system. According to David Wilson (10), stress is reduced by access to range, small flocks, and low stocking density. Since chickens are aggressive, being able to escape from each other reduces stress. Routine medication can often be eliminated on well-run pasture-based chicken farms; however, the possibility for disease outbreaks still exists.

Farmers should be aware that chickens raised by pasture-based methods are exposed more frequently to wild animals, which can transmit parasites and diseases. Salmonella may be transmitted by wild birds (17). Fowl cholera may especially be a problem in outdoor birds (17). One study showed that mortality can be higher in free-range than caged production (i.e. 15% compared to 4%) (21), but this depends on many factors.

Debeaking is generally not recommended for range birds—it makes foraging more difficult. Although cannibalism can be reduced by debeaking, many range flocks do not suffer from cannibalism.

Control of predators is necessary for outdoor flocks. Tight fences around the range area and housing where birds can be locked in at night can deter predators. Portable housing should have close contact points with the ground. Joel Salatin (5) has found that many predators will not cross a short-grass pasture in the daytime. Guardian animals such as well-trained dogs may be useful in combatting predators.

Weather conditions can be big variables for outdoor operations. The spread of disease is worse for outdoor birds during the times of the year when mosquitoes are active and during wet, rainy conditions. Mosquitoes spread some diseases such as fowl pox (17). Standing water and runoff from heavy rains can be health hazards for chickens on pasture, especially in portable pens. Pastured poultry producer Joel Salatin puts a hay pad under a roofed section of his field pens to allow the birds to get dry.

Larger birds can take the cold if they are dry; however, severe cold will freeze chickens' combs. If the temperature gets above 90° F, birds over seven weeks suffer—Salatin's field pens need to be slightly propped up for ventilation under these conditions. Shade may be necessary.

Internal parasite control is aided by pasture rotation, helping to prevent coccidiosis and worms that affect ranging chickens. Salatin does not return to the same plot of land for three years in his rotation and finds mortality from disease to be low (two to three percent). Most of the literature from the 30's and 40's, when birds were commonly pastured, recommends waiting at least one year before returning to the same plot of land. Birds can build up some resistance to coccidiosis as they get older, but they are susceptible when young. Keeping the grass short (two inches), by mowing or following a cattle rotation, aids in sanitizing the pasture—sunlight penetrates to the grass and soil.

Grower/writer Gail Damerow suggests eliminating intermediate hosts of internal parasites, such as snails, and avoiding mixing chickens of different ages as methods to prevent parasites (20).

General Management Concerns

For more information on general topics—managing breeders, brooding, natural incubation and hatching, molting, etc.—consult some of the publications on poultry production listed in the Resource Section.

Carcass disposal options are various. Burial and burning are often used to dispose of dead chickens, but composting is an alternative that recycles the carcasses. When composting is the option chosen, a carbon source such as sawdust or straw is added. When composting is properly done, temperatures above 130° F destroy pathogens and convert carcasses to fertilizer (22). The Extension Service in Maryland offers a video called "Composting Poultry Mortality" (23). One entrepreneur has fed poultry and hog carcasses to alligators.

Disposal pits are often used in large-scale production, but may be outlawed in some states because of concern about ground water pollution. With any method, it is recommended to be aware of local regulations about carcass disposal.

In large-scale confinement operations, chicken litter should be managed so that it becomes a resource instead of a source of pollution. Poultry litter is often spread on fields as a fertilizer or fed to cattle. These practices need to be done properly to assure that excess nutrients do not pollute the environment.

ATTRA can provide information on alternative methods of fly control in poultry housing. Integrated pest management is carried out with biological controls such as the release of wasps that parasitize fly pupae; physical controls such as light traps, baited traps, and nontoxic sticky tapes; and cultural controls such as removing moist manure, spilled feed, and drainage problems.

Processing and Marketing

For more information on slaughter, processing equipment, regulations, marketing, and the organic market, see the ATTRA publication <u>Processing and Marketing Chicken Products: Meat and Eggs.</u>

Integrating Chickens onto the Farm

Small-scale poultry production is complementary with vegetable production. Combining poultry production with vegetable production can provide weed and insect controls and fertilization benefits. Chickens eat insects in some vegetable crops, such as potatoes, without damaging the plants. Chickens may be allowed access to the garden after harvest to provide manure for increased soil fertility.

Ducks, guineafowl, and geese have also been used for controlling insects and weeds (24). In orchards, chickens and geese eat fallen, pest-damaged fruit and can be effective in weed and insect control. Researchers at Michigan State University (25) have studied the use of chickens and geese in orchards. Chickens were found to control insect pests while geese aided in weed control.

Chickens are sometimes used for tillage—clearing surface weeds and bulbs out of a plot of land and preparing the ground for planting vegetables. As described earlier, many permaculture systems use chickens for tillage, rotating chickens through fenced areas, where they stay for a period of several weeks, clearing out vegetation, scratching, and fertilizing the soil with their manure and preparing the ground for planting. Other livestock operations can be combined with chicken production. Grazing poultry can work well with other livestock in controlled rotational grazing. Organic beef operations can be enhanced by having chickens follow the cattle rotation and eat insects—chickens pick apart dung pats, destroying harbors for parasites and insect larvae.

Other Poultry in Sustainable Production

Turkeys are considered more fragile than chickens and more susceptible to disease, but turkeys are more aggressive foragers than chickens. On a small scale, market turkeys may be a seasonal operation, since poults could be started in June and ready for the holiday market in November. Contact ATTRA for information on adapting sustainable poultry production models for turkeys—the pastured poultry model, the free-range model, and the chicken tractor are commonly used with turkey production.

Weeder geese were used on a large scale in California in the '50s to weed cotton fields before the widespread use of herbicides. Geese have been used successfully to weed crops such as strawberries, potatoes, onions, etc. Geese have a strong preference for immature grasses but sometimes eat ripe fruits and berries.

Duck is more commonly eaten in Europe and Asia than in the U.S., where only three percent of the population eats duck (26). Ducks have been used for aquatic plant control in ponds, especially for duckweed and pondweed. Muscovy ducks have been used for fly control on dairy farms.

Of the common domestic species of poultry, only geese do well on a grass-only diet; chickens, turkeys, and ducks need some grain. Geese and ducks are more resistant to disease and parasites than chickens and turkeys, and, as waterfowl, are more able to withstand temperature extremes and wet weather. In addition to the meat and eggs provided by geese and ducks, these poultry provide other services such as insect, snail, and slug control.

Guineafowl are considered luxury food in Europe where they are raised commercially. Their pheasant-like meat is appreciated in the U.S., but they are raised primarily as foragers to control insects in pastures and gardens. Guineafowl and geese can also act as "watchdogs" due to their noisy calls when alarmed.

Poultry species are also valued for show and are exhibited. Some poultry enthusiasts are concerned about the preservation of minor breeds of poultry and believe a wide genetic diversity should be maintained. The American Livestock Breeds Conservancy (16) works to protect minor breeds from extinction, including poultry breeds.

Many other avian species are raised commercially, such as quail, pigeon and ratites. ATTRA can provide production information on these species, as well as on other forms of poultry—such as turkeys, geese (weeder), ducks, guineafowl, and gamebirds.

Further Resources

Extension and state Agricultural Experiment Stations have older literature (from the '30s and '40s) describing small-scale and pasture methods of raising poultry—this literature is available at land grant university libraries.

County and state Extension agents may be good sources of information on small-scale poultry production. The University of Maryland Extension service offers the publication, Sources of Poultry and Supplies for Small Flocks (27), that lists poultry resources for egg production, meat, turkeys, purebreeds, guineafowl, gamebirds, waterfowl, as well as equipment and supplies, etc. The 4-H clubs can support poultry production and may aid in providing good stock.

The Farming Alternatives Program at Cornell University in New York offers a Specialty Poultry Resources Information Package that discusses marketing poultry products, grazing poultry, organic poultry production, and resources (28).

A list of books and magazines dealing with small-scale and alternative poultry production follows at the end of this publication. A particularly useful book is Gail Damerow's A Guide to Raising Chickens (29). Other alternative poultry producers are also good sources of information.

Summary

Although the present poultry industry offers affordable products, many farmers are interested in alternative poultry production. Market potential exists for "farm-fresh" poultry products. Many models for pasture-based production exist—producers must decide which one best fits their needs. Alternative poultry production, usually small-scale, may involve a grazing component and emphasizes preventative measures for health maintenance.

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Diane Kaufman
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Chippewa Falls, WI 54729
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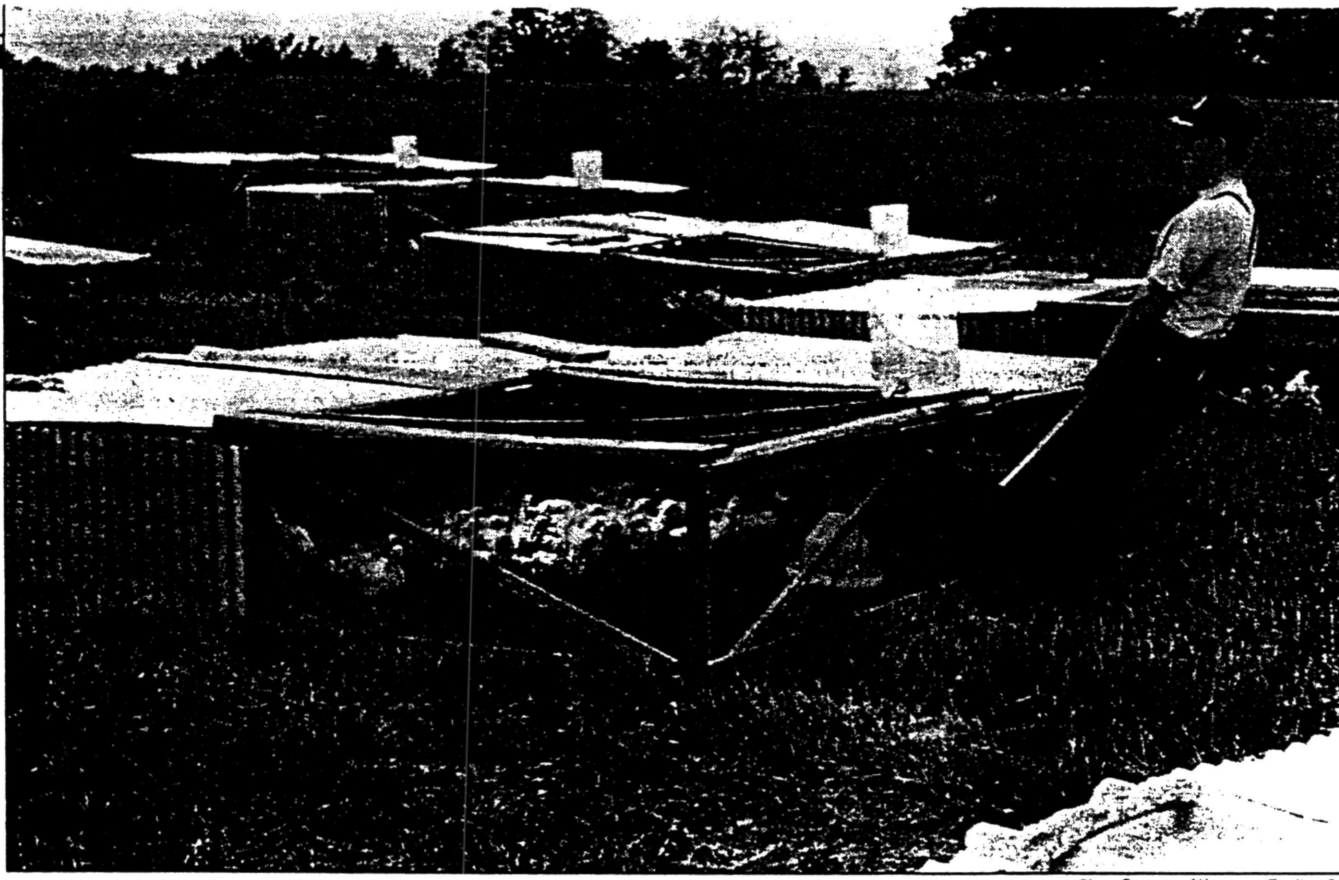

Joel Salatin moves his broilers to new pasture simply by pulling their crates into fresh grass. *Photo Courtesy of Necessary Trading Co.*

Profitable Poultry On Pasture

Broilers and layers follow beef cattle in this rotation.

MICHAEL TRAUPMAN

SWOOPE, Va.—Joel Salatin's pastures are for the birds. Ninety-five of his 550 acres are devoted largely to ranging chickens that help him *net* about $25,000 working only six months a year. Last year, Salatin produced more than 6,000 broilers and 3,000 dozen eggs—with pasture as the main feed source.

"Consumption of grain decreases as consumption of grass increases. It all keeps the expense side of production down," says Salatin. "A chicken will only consume so much grass. After all, a chicken is not a cow. But ... the freshness of the forage has everything to do with consumption. When we move them, they will eat more forage and more bugs and less grains." Pasturing has cut Salatin's feed expenses up to an estimated 60 percent on layers and 30 percent on broilers. Also, the broilers reach market weight two weeks earlier than normal.

While Salatin knows that his chickens prefer to graze on pastures with a legume, preferably clover, he is convinced that they do so well on pasture because they are moved often and are constantly getting fresh grass and manure to graze over. "The key is extremely frequent freshness. Animals have to have their beds changed—their linens cleaned and beds cleaned just like people. They eat much more if they, just like you and I, get fresh food and drink," he says.

Beef-Poultry Rotation

On Salatin's Polyface Farm, 50 head of beef graze pasture first. Controlled by portable electric fences, the cattle leave a trail of manure and 4 to 5 inches of grass stubble in their wake.

"The cows have to graze ahead ... and get the forage down to poultry levels," Salatin explains. Chickens are attracted to the lush regrowth stimulated by the grazing cattle. "One to 2 inches of grass residue is ideal. Four to 5 inches works fine, but 6 to 7 inches is difficult. Long grass also isn't as clean. The broilers mash it over and their manure will not make contact with the soil surface."

Four days after the cattle chow down on the grass, the chickens are put on that pasture to clean up after them. Salatin says both his layers and broilers love to pick through fresh manure for insects, including emerging fly maggots, and undigested food particles, both helpful sources of protein. "The chickens sanitize the field, eating the parasites," adds Salatin.

Chickens pasture a field only once in two years. After pasture is grazed by the chickens, hay is cut twice and stored for cattle feed in winter. Salatin now has nearly four years' worth of hay in storage.

(Continued to page 23)

PROFITABLE POULTRY
(Continued from page 20)

Pasturing In Pens

The American layer breeds are extremely aggressive. "They scratch ... and move. They'll graze all year and they'll go out in all kinds of weather. About the only thing that keeps them in the house is snow," Salatin says.

In contrast, he says, "The broilers ... are very lethargic. They are bred like a race car to eat a lot of feed and gain a lot of weight really fast. For them, the free-range concept doesn't work. They don't free-range. They stay around the feeder. You have to force them onto the pasture so they range."

The dissimilar grazing characteristics of the birds force Salatin to use two very different kinds of portable houses.

Cornish cross broilers spend all of their time in 10- × 12-foot pens that Salatin moves daily. Each wooden and aluminum pen is 2 feet high and holds 100 birds. One end of each pen is enclosed with an aluminum sheet and is always faced west into prevailing winds to minimize health problems in cold, wet weather. The other sides are wrapped in poultry netting to provide plenty of fresh air and sunlight. Salatin only raises broilers from April 1 to Oct. 1.

Pens include a removable feed trough and gravity-fed waterer. To save time, Salatin stores a pre-mixed ration of ground corn, soybean meal, meat and bone meal with a probiotic in old fuel tanks in the field. He places the pens in a V-shaped pattern. "By running the pens with a V formation, I don't have to keep access clear," he adds. "I don't need to make room for feeding and watering."

On one acre, Salatin is able to graze roughly 500 birds. He raises seven batches of broilers per season. Salatin moves the birds to fresh pasture every morning by sliding a 2-wheeled dolly under the pen and pulling it only a few feet. The chickens merely have to walk with the pen. "It only takes 1.5 minutes to move them and 1.5 to service," says Salatin.

A Rolling Henhouse

Free-ranging layers venture up to 30 yards from their portable pens, which Salatin calls eggmobiles. "The eggmobile would be worth it even if they didn't lay eggs," Salatin adds. "The beauty of this is, because the house is just a bed for them—the lunch counter and gymnasium are outside—you can cram them in pretty well in that house. They sleep in there. That's all they do. At night when they sleep, I don't even think half the floor is covered."

An eggmobile is simply a portable 12- × 20-foot wooden henhouse that holds 230 birds humanely. It has a lean-to roof that slants from 6 feet to 2 feet in height. The floor is wire mesh in summer and hay-covered plywood in the winter. Although there is a big door on each end, Salatin says you don't have to walk inside to care for the chickens or gather eggs. Laying boxes built around sides can easily be opened from the outside for egg removal.

More Grass, Less Grain

Salatin says he began to save money on grain when he realized his hens were not consuming the grain he was putting out. "I was mixing feed here and putting it in the eggmobile. Yet they were pretty much keeping off the grain. I thought maybe the recipe was off," he recalls. "So, I thought I'd let them tell me what they wanted."

Salatin arranged the feed in separate feed boxes, delivering it to the chickens cafeteria-style with a container each for wheat, barley and bone meal. The chickens made a clear choice. "Basically they were eating whole corn," says Salatin. "They eat only what they want. They get their protein from the grass, especially in the summer. What they need are carbohydrates. And those are the calories they get entirely in corn."

Salatin says he doesn't mind substituting inexpensive corn for much more costly feed, since the chickens are getting their necessary nutrients from the field. "Protein is expensive. Corn is relatively cheap. They are consuming the cheap part of the feed—seven cents a pound compared to 11 to 12 cents a pound."

In the summer months especially, his layers consume only seven pounds of feed per 100 chickens per day, costing roughly 77 cents per 100 birds. On other farms, Salatin says confined chickens will consume up to 30 pounds per 100 per day, for a cost of $2.10 per 100 birds. "That's significant savings," he adds.

Using a system he loosely modeled after Booker T. Whatley's Clientele Membership Club, Salatin sells roughly 6,000 broilers a year at $1.20 per pound, live weight, to more than 300 families each year. The average bird weighs about 4 to 4.6 pounds. Having slightly more than $2 in expenses for each bird, Salatin nets $2.80 a bird. ☐

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SUSTAINABLE EGG PRODUCTION

LIVESTOCK PRODUCTION GUIDE

ATTRA is the national sustainable agriculture information center funded by the USDA's Rural Business -- Cooperative Service.

Contents

The ATTRA publication Sustainable Chicken Production discusses several poultry production models in detail, including free-range, pastured poultry, semi-intensive, chicken tractor and others. Sustainable Egg Production is a companion publication which discusses adapting these pasture-based models for egg production; many small-scale producers also raise layers in the traditional chicken coop.

Layers need nestboxes with adequate bedding and, if you want to maintain egg production during the winter, winter protection along with extra light. Layers prefer to have roosts. Egg production may look attractive to some producers due to the lack of slaughter and a ready market for eggs; however, the most economical way for small-scale producers to dispose of spent hens is by slaughter and sale as stewing hens.

Refer to one of the many books available on small-scale poultry production for general information on layer management, including rate of lay, flock replacement, controlled lighting, molting, economic efficiencies, etc. Gail Damerow's book A Guide to Raising Chickens (1) has a useful discussion of eggs (i.e. egg collection, quality, safety, storage, etc.) Industry-focused books such as Poultry Science(2) have useful sections on egg inspection and quality.

Egg Production in the Pastured Poultry Model

Joel and Teresa Salatin (3) developed the pastured poultry model – a floorless field pen moved daily to fresh pasture—which has mainly been used for broilers. However, they are using it more for layer production in the past few years. Joel Salatin's book Pastured Poultry Profits (4) has a brief section on using the model for layers.

The Salatins raise about 2000 layers per year (1500 in pastured pens and 500 in "eggmobiles"). The eggs in the pastured pens cost about 50¢ per dozen to raise.
The layers are fed a balanced concentrate ration, but they eat 30% less feed concentrate since they are in pastured pens.

The eggs bring in a premium—about $2.00 per dozen—since they are farm-fresh and raised in a natural setting with wholesome feed. The yolks are brighter than store-bought eggs, and they hold together better in a pan. According to

Salatin, the bakery items made with these eggs stay moist and fresh twice as long.

Salatin retrofits his standard 10′ by 12′ pastured pen for layers and hangs nestboxes inside the pen. An 18-inch-wide hinged top (across the 10-ft dimension) opens for egg-gathering from 10 nest boxes attached to the top of the pen. The nest boxes are 12 inches deep and 12-inches wide. They are separated by 6-inch partition boards. If the nestboxes were not separated, then the layers would all lay in one spot and break the eggs. The nestboxes are about 12 inches off the ground. A perch board is lowered during the day, but pulled up at night to prevent the birds from roosting in the nestboxes at night. His thirty pens are placed alongside each other in a pasture with up to 50 layers in each.

Although the nestboxes add to the weight of the pen, it is still possible to move them by hand with a dolly. Producer Skip Polson uses plastic milk cases as a lightweight substitute for the wooden nestboxes. He hangs the boxes with the open side up, after cutting an access hole for the hens on one side (5).

Salatin uses Rhode Island Reds for pastured pen production. The "old-fashioned" type is better for pastured pen production than the "improved" production type, because, although it produces fewer eggs, it is less high-strung. Each bird should produce about 21 dozen eggs per year, which could sell at $1.50 to $2.00 per dozen.

Salatin expects a pen of 50 birds to produce 36 eggs per day during their first year of production. If they do not lay more than 50%, they do not pay the feed bill (6). However, during their second year, they produce less although the eggs tend to be jumbo-size. They keep the birds for two years because it can be difficult to market spent hens.

Labor is needed everyday to move the pens to fresh pasture and refill feed and water. It is important to gather the eggs two times per day in order to keep them from getting dirty. Washing the eggs can take a lot of time and reduces their "bloom" which keeps them fresh longer.

Problems include some incidence of pecking problems because the birds lower in the pecking order cannot run away in the confining pen. Some egg-eating also occurs because the birds do not have a lot to do. They are generally secure from predators in the pens.

Winter management is important because birds are kept for two years, going through one molt in that time. In Virginia, the birds would probably survive on the pasture during the winter but would not keep laying. At the Salatin farm, layers are housed in a 20′x120′ hoophouse during the winter. Although the hoophouse is unheated, composting deep litter provides some warmth. Egg production still falls by about 25%.

The hoophouse costs about $2000 to construct (or $1.00 per bird for 2000 birds). A neighbor of Salatin's used hog panels and plastic to build a makeshift greenhouse. Although the hoophouse works well in Virginia for housing layers in the winter and maintaining significant egg production, in colder climates, more substantial or heated housing and lighting may be necessary.

Salatin integrates the hoophouse with other farm operations. Rabbits are also moved into the hoophouse during the winter and kept in wire cages. Below the cages, a wire covering over the rabbit droppings keeps the chickens out of the manure bed which is used to produce worms. However, the chickens are allowed to roost on the wire during the day and add fertilizer. In the spring, the animals are removed and the hoophouse is used for vegetable production.

Since the birds are not on pasture in the winter, the yolks do not retain the bright color from eating forage. Salatin increases the amount of alfalfa in the diet and has experimented with sprouting grain in the greenhouse. His customers accept the fact that for the four winter months the eggs will be fewer in number and, although still a fresh, high-quality product, their yolks are not as bright as they are the rest of the year.

Batches of replacement pullets arrive twice per year. It is important to coordinate pullet pro duction with egg demand, since pullet eggs are small for their first two months of laying and more difficult to market. Salatin does not market these eggs—he sells them informally to customers dropping by the farm and gives some away as free samples. Chefs, however, provide a good market for small and/or cracked eggs.

Marketing spent hens is important. On the conventional market, spent hens bring very little—about 10¢ per bird. However, Salatin is able to net about $5.00 per spent hen by processing them on-farm and direct-marketing them as flavorful stewers to customers for $1.25 per pound. Salatin processes stewers regularly along with his broiler processing, since it would be more difficult to market large batches of processed stewers.

The pastured pen layer model is ideal for small acreages. If a producer has a larger acreage more than 50 acres), he/she may want to consider the "eggmobile." However, Salatin says the pastured poultry pens only net $3 per day with layers compared to $7 per day with broilers (6).

Free range: The "Eggmobile"

Joel Salatin developed a popular free-range model called the "eggmobile." It is briefly described in his book Pastured Poultry Profits (4). The 20' x 12' egg-mobile, built on a trailer hitch and housing 100 layers, is generally moved to fresh pasture every three or four days. Since the egg-mobile follows a beef cattle rotation, the layers pick apart cow dung pats for fly larvae. (Salatin deems this model worthwhile even if it were solely for fly and parasite control for the cattle.) The birds range for insects, gradually foraging to a maximum of about 200 yards from the egg-mobile. Whole grain supplement is provided cafeteria-style inside the egg-mobile. Allowing birds to forage on pasture reduces concentrate feed costs by 70% (4). Housing costs are also reduced—since the layers only stay inside the egg-mobile at night, one square foot per bird is enough space. The birds generally lay their eggs in the egg-mobile instead of outside; birds are locked in at night. In cold weather, bales of hay are added for bedding. Predators are not a problem, probably because of the frequent moves. The egg-mobile may return to a plot of land after just one month. An egg-mobile of this size requires a lot of acreage (about 50 acres); however, large egg-mobiles in particular, work well in combination with other livestock grazing operations.

This model costs less than the pastured pens to operate; the eggs only cost 25¢ per dozen to raise. The lower cost is due to the fact that less feed is used and whole grains are fed instead of a mixed ration. Corn, wheat, oystershell, and meat scraps are offered cafeteria-style, so the birds choose what they need. If, for example, the birds have been eating a lot of grasshoppers on pasture, they may consume less of the expensive meat scraps. If a producer were interested in certified organic production, this model could make costly organic feeding more feasible. Whole organic grains could be purchased and fed without the additional processing costs of grinding and mixing into rations. A further advantage of feeding whole grains is that nutrients that are lost during grinding are retained.

Compared to layer production in the pastured pens, labor is lower with the eggmobile, because feed and water do not need to be refreshed daily. The eggmobile is easier to move since it is pulled by a tractor and does not need to be moved daily.

Since the layers only visit the eggmobile to eat, lay, and sleep, losses from pecking order disturbances and egg-eating are less. Eggs can be gathered less frequently since the eggs do not get as dirty. The egg quality seems to be even higher with the eggmobile since the birds' diets are so varied. However, predation is more common with the eggmobile than with the pastured pens. If a neighbor's dog attacks, 50 birds may be lost instead of 10.

Salatin's eggmobile currently holds about 200 layers. Since the birds only stay inside the eggmobile at night, one square foot per bird is sufficient space. Since the moving and servicing of the eggmobile is a fixed cost (6), the cost-effectiveness of production can be increased by building a bigger eggmobile for more birds, but the eggmobile becomes unwieldy to move. He put 270 layers into his 12'x20' eggmobile in 1997 and it worked fine, but he is working on a model to house 400.

Salatin plans to move the layers from his field pen pastured poultry operation into the eggmobile during their second year since it costs less to maintain them there. Also, since predation losses are higher for the eggmobile, at least they would be older hens that are lost. When the layers are newly placed in the eggmobile, it is important to wrap poultry netting around the bottom of the eggmobile the first night so they learn to go in. Salatin believes that the eggmobile offers the best quality egg from a nutritional and taste standpoint. The color of the yolk does not fluctuate as much according to the season as they do with the pastured poultry field pens. The yolks from the eggmobile model always have a rich color.

Labor considerations have to be made when comparing the two models. The eggmobile, like the pastured poultry model, is shut down during the winter. The pastured pens have to be moved and serviced individually every day. To move the eggmobile, it takes at least 30 minutes to start up a tractor, drive to the site, hitch, move, unhitch, and drive home.

There are other models of free-range layer production in existence. Blue-prints for a portable coop are available from University of California Extension (7). Bishop wrote Protected Free-Range: Moveable Henhouse with Free-Access Range Run for Single-Sire Flock of 25 (8).

Semi-intensive layer production

"Semi-intensive" refers to permanent housing with access provided to a yard or pasture. An example is the layer operation of Ohio farmer Herman Beck-Chenoweth (9). He houses 500 layers in a barn and allows them access to range any day when the temperature is at least 15°F. He suggests putting up a perimeter fence about 1000 square feet around the barn and subdividing this area into at least 4 paddocks. Anytime more than 20% of a paddock begins to show bare ground, the birds should be rotated to a new paddock. The system is described in more detail in his book Free-Range Poultry Production and Marketing (10). Entrepreneur David Wilson (11) currently raises layers in a semi-intensive model. He led an effort in the early 90's to establish ranged broiler production (with a French broiler breed). He produces "specialty" eggs.

See the ATTRA publication Sustainable Chicken Production for a more in-depth description of the semi-intensive model where it is discussed for broiler production.

Innovative: Chicken Tractor

The "chicken tractor", developed by Andy Lee and discussed in his book The Chicken Tractor (12), is designed to be integrated with vegetable production. It is a floorless pen, usually 4'x10', enclosed with chicken wire and a covered top as protection against the weather. About 10 layers are kept in a pen this size. The pen is moved daily on fallow beds.

When using the chicken tractor model, many producers add a small house to the chicken tractor to provide more protection from the weather and keep the nestboxes in there. The house may need to be on wheels in ensure it is portable. Andy Lee finds that layers prefer to have their nestboxes at least 6 inches off the ground. Virginia producers Vicki and Charley Dunaway found that layers got bored in the chicken tractor and pecked each other, especially with the stationary use of the chicken tractor (13). The Dunaways attached a large corral to the chicken tractor in which the layers roam during the day.

Coops

Joel Salatin (3) also has experimented with a loose-housed bird production model. One model he uses is a house which combines rabbit production with chickens. The rabbits are kept in wire cages and the chicken scratch through the rabbit droppings, aerating the deep litter bedding, and producing compost. Salatin believes indoor flocks should consist of no more than 300 birds. He also believes that stocking density should be no more than one bird per 3 square feet. Otherwise, the manure load exceeds the bird's ability to scratch it into the deep litter. The advantage of this model is low labor compared to the pasture-based models.

A "composting chicken house" is discussed in the ATTRA publication Sustainable Chicken Production.

When developing an egg production model on your farm, remember it may be helpful to refer to books on poultry and egg production for more layer management information. Several books are listed in the Resource Section of Sustainable Chicken Production. Also, see the companionATTRA publications Feeding Chickens and Processing and Marketing Chicken Products: Meat and Eggs.

Summary

There are several pasture-based models and innovative coops for poultry production which are adaptable to layers—the producer must decide which is the most appropriate model for his/her farm.

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Rt. 1, Box 281
Swoope, VA 24479
(540) 885-3590

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Ridgeland, MS 39158-2300
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1436 Century Rd.
Auburn, KY 42206
502-542-6928

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1702 Mountain View Rd.
Buena Vista, VA 24416
540-261-8775 ($19.95)

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P.O. Box 186
Willis, VA 24380
540-789-7877
(Send SAS envelop)

Enclosure:

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Prepared by Anne Fanatico, ATTRA Technical Specialist.

February 1998

Editor's note - these publications are printed here as they went out on Earth Day, with minor changes.

THE "EGGMOBILE"

An ecological method for raising layers by Joel Salatin

A publication of the Virginia Association of Biological Farmers April 1990 25 cents

Several years ago I began pondering. How could I eliminate the soil impaction of a chicken yard, reduce feed costs, feed chickens bugs and fresh green material daily without taking it to them, and give layers unlimited fresh range?

A moveable henhouse! That was it!

I built a portable 6 ft. x 8 ft. chicken house on bicycle wheels and made a yard from 3/8" rod welded into rectangular gates, 10 feet long and 4 feet high. The gates, in two pairs of three, stood up like an accordion fence, a hexagon off the rolling house, which could be pushed from place to place. Rotating the yard around the mesh-floored house gave several days' fresh range per house-move.

It worked well enough that I abandoned the portable yard for a 3-point tractor hitch hookup on the house so I could totally free range the birds and move them easily over long distances. My object was to see how much feed they would pick up and what they would do to cow pats in the paddocks where cows grazed. The prototype provided enough answers that we expanded our laying flock to 100 and built a portable 20' x 12' "Eggmobile." It's the best thing since toilet paper.

The most dramatic difference between limited range (such as in the portable cages we use for meat chickens) and total free range was in feed consumed. They were eating about $3.50 to $4.00 worth of feed per day, much of it soybean meal and meat scrap (meat and bone meal), which are both protein sources and quite expensive. After being placed in the "Eggmobile," their daily feed cost dropped to about 70 cents. The entire first season they have refused to eat any soybean meal and the meat scraps have molded in the feeder. They want only whole corn and a small grain (rye, oats, barley). I put it in separate feeders, cafeteria-style, so they can pick what they want.

I feed no oyster shells, grit or trace minerals. Egg production dropped slightly, but instead of a dozen eggs costing 60 cents in feed, it now costs less than 20 cents. Besides, the birds will last three years instead of burning out at one or two. The yolks became sharply darker (more nutritious) and keeping quality, to the best we can determine it, is about three months. This reduces the perishability and increases the marketability of the product.

Harder to quantify, of course, but no less important, are the livestock and nutrient cycling benefits. The hens will range up to 200 yards from their house, beginning the first day fairly close and going out in concentric circles for about 3-4 days until the 200 yard limit is reached. As they exhaust the immediate range food supply, they expand their range area.

Because of their reduced protein consumption, I figure the flock is eating about 12-15 pounds of proteinaceous critters per day, the bulk of which are insects (grasshoppers, crickets). A significant portion of their protein, judging by the way they totally obliterate cow paddies, is fly larvae. Cow paddies scuffed up by hoof action, tractor tires or my booted feet are not scratched by the birds. They pick only those unmolested ones permeated with bug holes. While the chickens eat parasites and fly larvae, then, they spread droppings for much quicker breakdown, which aids in reducing the "repugnance zone" when cattle regraze the paddock a couple of weeks later. When the birds have been in a location for five days, they begin eating the meat scraps (protein) and their production declines enough to notice. By the second day at a new location, production increases and again they are disinterested in protein. The ideal move periods, then, correspond exactly with the livestock paddock shifts, which are timed to eliminate regrazing forage regrowth. By moving the chickens a paddock behind the cows we allow them to take advantage of the newly uncovered insects, the fly larvae which hatch in four days, and they help to spread the droppings. I've concluded that the "Eggmobile" is worth having even if the chickens never laid an egg. But for such a wonderful life, they say "thank you" with eggs.

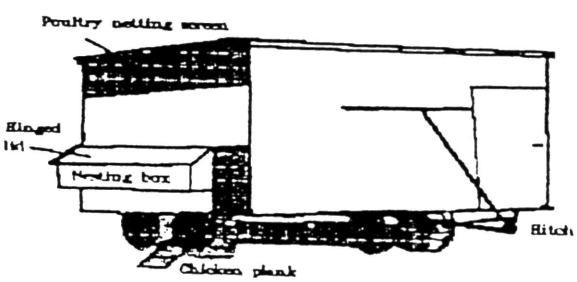
Another advantage of this approach is that housing costs become minimal. The house, instead of being living room, kitchen, bath, bedroom and recreation (gymnasium?), is merely bedroom and snack counter. While humane loose housing may require more than 3 square feet per bird, ours are happy with one square foot or less. Every morning they can roam fresh range to their hearts' content.

Our "Eggmobile" was built for under $150 (the 1" x 2" hardware cloth was the most expensive part) using scrap materials. Buying it all new, the materials would cost about $500, not including labor. The nest boxes line the sides of the trailer-type house for easy access from outside. A front and back door make it easy for us humans to enter, and a small door and ramp allow the birds easy access. I usually close their door at night for predator control. A hinged board in front of the next boxes keeps the chickens from roosting in and soiling the 1' square cubicles.

The inside dimensions are 5' on the lower side and 7' on the upper side, making a single slant, shed-type roof. The high side has a 2' band of 1" poultry netting at the top under the eave for ventilation, and one end has 3 feet of translucent screen glass for more light. Otherwise, the walls are steel roofing. For winter, I'll put skirts down to block cold air or put down plywood and shavings on the floor.

Predators have not been a problem. Not only are the chickens close to the cattle, but the frequent moves apparently keep predators leery of attacking something so unfamiliar in their surroundings. I've gone days in a row without shutting the chickens' access door at night, with no problems.

On an economic basis, I'll put our "Eggmobile" up against any other commercial model. Not because it was my project, but because it best meets the needs of more animals and people than any production model I've seen.



The "Eggmobile"

Joel Salatin is a long-time VABF member, farmer and writer living near Staunton, VA. He has recently been featured in Country Journal *magazine and others for his innovative farming practices.*

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ATTRA

Appropriate Technology Transfer for Rural Areas

FEEDING CHICKENS

LIVESTOCK PRODUCTION GUIDE

ATTRA is the national sustainable agriculture information center funded by the USDA's Rural Business -- Cooperative Service.

Contents

An important part of raising chickens is feeding—feeding makes up the major cost of production and good nutrition is reflected in the bird's performance and its products. This publication discusses feeding traditional rations as well as mixing your own rations, organic diets, and special concerns for feeding chickens in some of the pasture-based models discussed in the companion ATTRA publication Sustainable Chicken Production.

Other related ATTRA publications are Sustainable Egg Production and Processing and Marketing Chicken Products: Meat and Eggs.

Feeding Options

The most convenient way of feeding chickens is with a balanced pelleted ration, whether the birds are confined indoors or allowed to range outdoors. Most diets contain corn for energy, soybean meal for protein, and vitamin and mineral supplements. Commercial rations often contain antibiotics and arsenicals to promote health and improve growth, coccidiostats for combating coccidiosis, and sometimes mold inhibitors. However, it is possible to obtain unmedicated feed—check feed labels to see if they contain feed additives.

In the industry, the feed is pelleted so the bird can eat more at one time. Chickens are nibblers and make frequent trips to the feed trough for small meals, which requires energy. Pelleting reduces the amount of energy required for a bird to feed. However, many producers of pasture-based, "natural" poultry believe that the meat is better when the bird receives more exercise.

If the bird is eating a fibrous diet, grit such as oyster shells is supplied to aid in grinding up coarse feed in the gizzard. Industry birds usually don't use grit because the diet is low in fiber. Outdoor birds also pick up small stones.

Different rations are often used, depending on the production stage of the bird. Starter rations are high in protein—an expensive feed ingredient. However, grower and finisher rations can be lower in protein since older birds require less. A starter diet is about 24% protein, grower diet 20% protein, and finisher diet 18% protein (1). Layer diets generally have about 16% protein. Special diets are available for broilers, pullets, layers, and breeders. Whole grains can also be provided as scratch grains.

Access to clean water is important. Levels of total dissolved solids above 3000 ppm in the water can interfere with poultry health and production.

Home-mixed Rations

Some producers decide to mix their own rations in order to be assured that only "natural" ingredients are used.

Poultry feed ingredients include energy concentrates such as corn, oats, wheat, barley, sorghum, and milling by-products. Protein concentrates include soybean meal and other oilseed meals (peanut, sesame, safflower, sunflower, etc.), cottonseed meal, animal protein sources (meat and bone meal, dried whey, fish meal, etc.), grain legumes such as dry beans and field peas, and alfalfa. Grains are usually ground to improve digestibility. Soybeans need to be heated—usually by extruding or roasting—before feeding in order to deactivate a protein inhibitor. Soybeans are usually fed in the form of soybean meal, not in "full-fat" form, because the valuable oil is extracted first. Whole, roasted soybeans are high in fat which provides energy to the birds.

Chicken feed usually contains soybean meal which is a by-product of the oilseed industry. In the industry, soybeans are dehulled and cut into thin pieces (flaked) to improve the action of the solvent (usually hexane) which is passed through the soybean to extract the valuable oil. Vegetable oils such as soybean oil are used for edible and industrial purposes. Then the soybean is then toasted as a method of heat treatment to deactivate an inhibitor which would otherwise interfere with protein digestion in the animal.

However, chickens can also be fed unextracted (full-fat) soybeans. An advantage of feeding unextracted soybeans is that they still contain the oil which provides high energy fat to the bird. Unextracted soybeans need to be heat-treated—roasted with dry heat and then ground, rolled, or flaked before mixing into a diet. Another method of heat treatment is extruding. Extrusion involves forcing the beans through die holes in an expander-extruder which creates friction which heats the beans sufficiently (sometimes steam is also applied). The result is a powdery material which does not require further grinding. Roasted and extruded soybeans should not be stored for long periods of time, especially in hot weather, because the oil turns rancid.

Since protein is generally one of the most expensive feed ingredients, the industry uses targeted rations and reduce the amount of protein in the diet as the birds grow (chickens require less and less protein as they age); however, it may not be cost-effective for small-scale producers to have different diets for starters, growers, and finishers.

Vitamin pre-mix is usually added but may be reduced by using vitamin-rich plant sources such as alfalfa. Other plants also provide vitamins in their leaves, hulls, and brans. Fish oil can provide vitamins A and D. Yeast provides some of the B vitamins. Sunlight is a good source of vitamin D for ranging chickens (converting a precursor to vitamin D). Poultry in cattle pastures may obtain vitamin B12 when picking through dung pats for insect larva.

Sprouting grains, although a labor-intensive process, is used by some producers for vitamins when access to range is not possible. Sprouting can increase the amounts of carotene (vitamin A precursor) in the grain and as a source of year-round forage, could be an advantage for certified organic poultry production to reduce the amount of synthetic vitamins required in the diet. Eating plants may provide a yellow color to the skin of slaughtered chickens and a deeper yellow color to egg yolks.

Trace mineralized salt is usually added to poultry diets, but other sources can provide minerals. Minerals, although not present in high levels in plants, are provided in fish meal and kelp (seaweed). Meat and bone meal is an excellent source of minerals, particularly calcium and phosphorus, as well as being a good protein source. However, if a producer does not want to use meat and bone meal, then dicalcium phosphate can be substituted.

Access to pasture can reduce the vitamins and minerals needed in the diet since the birds get vitamins from plants and both vitamins and minerals from insects. An example of an all-grain diet is enclosed.

Probiotics are sometimes provided to chicks during placement and before shipping. However, preparing a balanced diet can be a complex, possibly costly process, especially for producers with little background in nutrition. Specialized knowledge is required about the nutrient requirements of chickens and the nutrients contained in feedstuffs. Feed ingredients need to be sourced, milled, mixed together according to a formulation, and the mix is usually pelleted.

Ration-balancing of home-made diets is important, especially on a commercial scale, to achieve the right amounts of nutrients. If diets are not properly balanced, then birds will suffer from nutritional diseases. The National Research Council's Nutrient Requirements for Poultry (2) specifies the amounts of protein, energy (carbohydrates and fats), minerals, and vitamins. The quality of the protein is important since it is made up of individual amino acids, some amino acids being essential to bird health.

The proper amount of these nutrients needed in diets depend on breed, age, and type of production. The reference issue of Feedstuffs magazine (3) has a charts of feed composition which lists the amount of nutrients provided by various feedstuffs. Feeding textbooks such as Applied Animal Nutrition: Feeds and Feeding (1) also have such charts. Feedstuffs can also be analyzed in a laboratory for nutrient make-up. Poultry nutritionists or Extension agents can provide help in ration-balancing. In preparing your own diet, formulation is important. Sample diets are enclosed. Some diets do not include meat and bone meal--call ATTRA for more information.

If you are mixing a large volume, you may be able to get a local feedmill to mill, mix, and possibly pelleted (requires different machinery) for you. Feedmills also have access to feed ingredients and staff with nutritional expertise who can formulate diets.

Ellie MacDougal (4), a Maine farmer who keeps 50 layers primarily for composted litter for an herb operation, is an example of a producer who mills and mixes her own ingredients on-farm. She purchases whole grains and mills them as needed to retain nutrients. She says that milled grains should be fed within 30 days or else they begin to lose nutrients. She suggests a hand-mill for small quantities or a motorized mill for larger amounts (5). Another option is to buy already milled grains and just do your own mixing.

Some producers feed whole grains. An "old-fashioned" way of feeding chickens is the "mash and grain" method which is a two-feed system of providing whole grains along with a high-protein ration in order to reduce costs. The whole grains cost less than the high-protein ration and can even be grown on-farm (6). Contact ATTRA for more information on mash and grain feeding.

Certified Organic Diets

Home-mixed diets are particularly useful to certified organic poultry producers. Although pre-mixed organic poultry rations are available for purchase, they can be expensive and may need to be shipped from long distances. Call ATTRA for a list of organic poultry feed suppliers.

Many producers look for local sources of organic feed ingredients. If you have difficulty in finding sources of organic feedstuffs locally, the Organic Crop Improvement Association (OCIA) (7) may be able to provide you with the names of organic producers in your area. Some producers raise their own organic feedstuffs.

A useful contact is Craig Kovacik (8), an organic poultry producer in Michigan. He raises an average of 50 broilers per week in a pasture-based model. He mixes and sells organic poultry rations and is familiar with organic standards for processing feed.

At present, the USDA does not permit "organic" labels for livestock products, because the federal standards are not yet set for organic livestock production. However, private and state certifying agencies provide certification is an operation meets their criteria. Most programs' standards for certified livestock production require that 100% of the feed be certified organic and that no antibiotics, wormers, growth promotants or insecticides which are not on the program's list of approved natural products be used.

Feeding Concerns for Chickens in Pasture-based Models

When raising birds in a pasture-based model, it is important to keep in mind that the digestive system of the chicken is geared towards the digestion of insects, seeds, and grain rather than the digestion of forage, and they will still need concentrate feed rations to produce well. However, chickens can make some use of high-quality forages, particularly legumes. Ladino clover was a recommended forage in the 30's and 40's when grazing poultry was more common. Sudan grass was used for summer grazing, oats and wheat were used in the winter, and alfalfa provided perennial legume pasture.

Joel Salatin (9) developed the popular "pastured poultry" model in which broilers are pastured in floorless pens which are moved daily to fresh pasture. Feed concentrate is provided in the pen, along with water. In this system, allowing the birds to forage on plants, seeds, insects, and worms which reduces concentrate feed costs by 30%. (See the ATTRA publication <u>Sustainable Chicken Production</u> for more information.) Salatin does not believe that forage species is important for poultry range. He believes that a diverse, perennial mix of forages is key to providing nutrients. He says the forage height is important and keeps his pasture sward at about 2 inches.

If the grass is tall, chickens in the confined field pens ("pastured poultry") tend to mat the grass down and it becomes unsanitary. Fresh, vegetative pasture provides more nutrients to poultry than fibrous, stemmy pasture, and a good sod pasture prevents muddy, unsanitary conditions. Some producers use mangles, kale and even tree forage, such as mulberry or persimmon, as poultry feed.

Salatin also developed a free-range model called the "eggmobile." This is a portable layer house which is moved every few days to a new pasture location. Birds range freely during the day (see the ATTRA publication <u>Sustainable Egg Production</u> for more information). If chickens (particularly the more aggressive layer breeds) are raised in a "free-range" model such as the eggmobile, it may be possible to feed whole grains cafeteria-style instead of milled, mixed rations. Salatin feeds whole grains to his layers in the "eggmobile". Corn, wheat, oystershell, and meat scraps are fed cafeteria-style, so the birds can choose what they need.

If, for example, the birds have been eating a lot of grasshoppers on pasture, they may consume less of the expensive meat scraps. This style of feeding may make costly organic feeding more feasible, since whole organic grains could be purchased and fed without the additional processing costs of milling and mixing into rations. However, birds in the confined field pens of the pastured poultry model may not be able to forage sufficient insects.

Although feed requirements can be reduced by allowing access to range and the accompanying insects, benefits of ranging poultry may lie more in marketing and animal welfare rather than in the feeding.

Summary:

Chicken nutrition and feeding is an important part of production. If you are going to mix your own diet, great effort may be required to produce well-balanced diets, especially certified organic diets. Chickens are able to obtain some of their nutrients from insects, worms, and plants when on pasture, thus reducing costs.

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P.O. Box 2400
Minnetonka, MN 55343
1-800-888-7580
Reference issues: $35.00

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Blue Sky Farm
Wells, ME 04090
(Prefers to be contacted by mail)

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1001 Y Street, Suite B
Lincoln, NE 68508-1172
402-477-2323

8) Craig Kovacic
CVK Farms
5605 Ewalt Rd.
Imlay City, MI 48444
810-724-1476

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**Prepared by Anne Fanatico,
ATTRA Technical Specialist.**

February 1998

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All-Natural Laying Hen Diet

Ingredient	Percent
Ground yellow corn	34.5
Ground oats	20.0
Wheat bran	15.0
Wheat middlings	10.0
Alfalfa meal (17%)	3.0
Dried skim milk	2.0
Fish meal (60%)	2.5
Meat and bone scraps	3.0
Soybean meal (44%)	2.5
Oyster shell flour	5.0
Steamed bone meal	1.5
Salt	0.6
Fish oil (2000 A; 400 D)	0.4
Total	100.0
Percent protein (calc.)	14.8
Metabolizable energy (Cal/kg)	2359

Barton, Lionel. 1967. PhD Thesis: Fatty Liver Studies in Laying Hens. Michigan State University, East Lansing, MI. p. 36.

Sustainable Farming Network

The network provides a needed link, enabling farmers to help each other by sharing questions, concerns and information relevant to their farming operations. We recognize there's a lot of practical knowledge on resource efficient farming out there that isn't being circulated. If you have any questions, problems, helpful hints or new techniques which you would like to share, then send them to:

Sustainable Farming Network, Box 125, Ste. Anne de Bellevue Que. H9X 1C0 or Fax: 514-398-7972

Question: ***I am looking for an organic starter feed formula for my chicks. Could you provide some suggestions?***

L. Bender
Tavistock, ON

Answer: The chicken should have a properly balanced diet of energy, protein (including a full complement of the required amino acids), vitamins, and micro and macro minerals. Specific nutritional requirements change depending on stages of growth:

starter - from 0 to 3 weeks
grower - from 3 to 8 weeks
finisher - from 8 weeks to slaughter

Generally, though, it is impractical to have more than 2 separate preparations. Therefore feed is formulated for the 0 to 3 or 4 week period and for a finishing ration from 4 weeks to slaughter.

The best possible ration mix will change from farm to farm depending on available on-farm feeds and affordable purchased feeds that can provide a high quality nutrient source for the chickens.

Starters grow more quickly than finishers, so they require a feed with a slightly higher protein ratio. The following are a few examples of basic starter rations:

Corn can be partially replaced by wheat, but the protein content will increase and an energy deficit will result.

Peas will have a lower protein and energy content than fababeans, but they also have lower tannin levels. Consequently, pea substitution may improve digestibility.

For more information refer to:
Elevage Biologique du Poulet de Rapport (Report on Organic Poultry Production). Phillipe Georgeot, Nature et Progres: France.
L'Elevage Biologique. 1979. Jean-Claude Rodet.

These two documents are available through the EAP (Ecological Agricultural Projects), Box 191, Macdonald College, Ste. Anne de Bellevue, QC, H9X 1C0. (514)398-7771. Thanks to Suzanne Cazelais for providing the information.

Question: I am currently growing approximately 200 acres of potatoes in rotation with a rye green manure crop. The rye is seeded in the fall following potato harvest and disced in at heading the following year. Regrowth from the disced in rye covers the soil for the remainder of the year. The main problem with the system is that in some fields, potatoes are having problems with root knot and root lesion nematodes and apparently the rye is a host crop. The manufacturer of Temik which is used to control the nematodes has voluntarily withdrawn the product from the market for 1990 because of potential residue problems. Do you have any suggestions for alternative green manure species and non-chemical control measures for nematodes?

F. Racz
Ste. Thomas de Joliette, Quebec

Answer: One recent study in Michigan and extensive tests in Maine in

Ingredient	%
Corn	67.7
Soybean meal	21
Brewers yeast	5
Corn gluten	4
Calcium Carbonate	1
Calcium Phosphate	1
Salt	0.3

Protein: 20.77%
Energy: 2.96 KCal/kg

Ingredient	%
Corn	50
Wheat	5
Oats	5
Alfalfa meal	3
Soybean meal	20
Fish meal	5
Meat scraps	5
Dried whey	3
Brewers yeast	3
Ground limestone (dolomitic)	1

Protein: 17-20%

Ingredient	%
Barley	50
Oats	15
Fababeans or peas	10
Soybean meal	10
Dehydrated alfalfa	5
Dehydrated fish meal	4
Green algae	4
Organic mineral additive	2
Sea salt	0.3

APPPA Grit!

American Pastured Poultry Producers' Association

Volume 1 Issue 2 Summer, 1997

On-Farm Research and Snake Oil!

by Joel Salatin

Each year new difficulties arise that sometimes make us wonder how long we can continue to raise industrial birds on pasture. As the industry selects for certain genetic traits for a production model going 180 degrees different than ours, we must be more and more creative in order to get satisfactory performance.

In the last couple of years we have actually wondered how long we can continue to use regular hatchery birds and the "normal" feedstuffs. The quality of both feed and birds has deteriorated dramatically in the nearly 15 years we've been raising these broilers. The industry selects for birds that can gain faster on higher calorie feeds. To compensate for the physiological strain this puts on bones, tendons, organs and nerves, the industry develops ever stronger medications, hormones, arsenicals and vaccines.

Each year the birds need higher octane and more engine finetuning in order to perform but our paradigm calls for leaded, stodgy fuel and no mechanics to tweak the engine every few hours As we and the industry move farther and farther apart, we find it nearly impossible to get good performance from the same ration we've always used.

In addition, when we started people weren't feeding dead cows to cows and you could get rendered animal proteins from fairly pure sources--all cow, for example. But over the years, pure-species animal protein has become virtually impossible to get. Every one on the market contains some poultry by-products, which pushes us into feeding industrial dead chickens back to our chickens.

Not only is that unnatural and philosophically reprehensible, it is the slippery slope that has lead to mad cow disease in Britain and who knows how many animal diseases.

We finally realized last year that we could no longer feed just "natural" things to these chickens and have them perform; we needed to upgrade the octane with some high-tech biologicals. Obviously, we didn't want to use medications and synthetics but there are some high-powered biological extracts, some genuine hyped-up nonsynthetic snake oil. We simply could not get enough vitamins and minerals into these birds from natural feedstuffs to get decent performance because these birds were completely different than the ones we had a decade ago.

Media Learns Pros of Pastured Poultry Production

An Agricultural Commentary by Diana L. Robinson

Mainstream media has fallen far short of providing accurate, broad-based coverage of agricultural issues. It sometime seems that just the word "farming" is enough to put the average reporter into a coma.

There are several reasons for this- the largest being the fact that few reporters have any personal experience in the profession of farming. The ag community, however, also has a share of the blame in this situation.

Farmers are notorious for "singing to the choir." They generally have a very sharp perception of industry problems and improvements, but they tend to keep these discussions to themselves, rather than taking steps to raise public awareness.

In an unusual move, a small but growing group of agriculturalists recently took steps to rectify this situation locally.

The New York State Pastured Poultry Producers Association, a project of the South Central Resource, Conservation and Development Agency (R.C.&D.) of Norwich decided to perform some consciousness raising among members of the print media. They chose a most spectacular method of introducing a topic that might have gotten very short attention from this group.

Though popular in niche markets, Pastured Poultry is still relatively

SNAKE OIL - Continued from Page 1

As I travel around the country, I ask a lot of questions to see what I can learn from folks who are creatively refining this pastured poultry model. In addition, most conferences have trade shows with every kind of nutritional product and promise you can imagine. The problem is that all these product sales reps show charts that compare their product to nothing.

It's always "ours" compared to "'nothing." But you and I don't make decisions that way. We need to decide, among several options, which is best. But these products don't compare themselves to each other; the control group is always "nothing." So which snake oil should I buy?

We've tried numerous things over the years. We tried Nutri-Carb and nearly killed half a batch of chickens. We tried hydrogen peroxide, with no results. Over the years, when someone promised a great solution, we'd try it. That's how we came up with the Conklin Fastrack probiotic--others were just glorified minerals with enough bugs thrown in to be called a probiotic. The Fastrack really gave us results in reduced late-growth heart attacks.

For sure, we do not ever intend to go back to animal proteins.

We resolved, therefore, to run trials this year comparing these competing snake oils with each other, dividing our flocks and running these products head to head to see which would give us the best performance. We measure performance first in terms of mortality and secondly weight gain. Since we don't mask sickness with medications or vaccines, health is real and not a charade.

The first batch of 1,300 this spring we divided into four groups of 325. One received our regular old ration. Group two received the regular ration plus Immuno-Boost, a water supplement. The third group received the regular old ration plus Willard's Water, a catalyst altered water supplement. The fourth group received no water supplements but rather a ration and feed supplement (Nutri-balancer) containing NO animal protein developed by Fertrell, an organic soil amendment company that has been in business for nearly 30 years.

Very shortly we noticed that all three supplemented batches spun circles around the control. This was enough to prove that our hunch about needing to look at some snake oils was well founded. All three of these groups performed extremely well. Imagine how elated we were to find the Fertrell Nutri-balancer group doing so well without any animal protein except some low-heat fish meal (Sea-Lac).

As we went to the field, things rocked along but the Immuno-Boost clogged up the waterers terribly and we abandoned that product. With the Fertrell birds doing so well, we finally switched everything to that and did not run the trial completely to the end since we are in the profit business, not the pure research business.

Incredibly impressed with what we were seeing from the Willard's Water, we broke the next batch into a group of Fertrell only and Fertrell plus Willard's. Of course, we joked about having 10-pound birds in 2 weeks and all the stuff that goes with experimenting with snake oils.

Interestingly, adding the Willard's Water to the Fertrell did not make an iota of difference. We determined that we could not make the birds "weller". Once they are well, they are well and that's that. Now we've abandoned the Willard's Water and intend to try some other snake oils to see if we get any benefits.

We are pleased enough with the Fertrell supplement that we have put all layers and broilers on it as our new "control" and will begin running trials from this new benchmark. We also want to give some competitors a shot at the ration, specifically Leland Taylor and his Clodbuster stuff, as well as Dyna-min and others--do you have ideas?

I really believe that this type of research is sorely needed, but it cannot be funded by companies or institutions or it can be biased. All I want is what performs, plain and simple. I have purchased, at full retail price, every ounce of every product I've used. Any trial that uses "free" product should be questioned for integrity. I am not trying to hurt or help anybody except to share our experiences with practitioners who are smart enough to make their own decisions.

For sure, we do not ever intend to go back to animal proteins. The theory is that the minerals cause the body to metabolize the proteins in the grains. As we've reduced the minerals in our soils through chemical fertilizers, we've reduced the vitamin-mineral content of our grains and hence the body's ability to extract the nutrients that are there.

By properly supplementing with minerals, it makes everything kick in like it should. Pretty fascinating. To think that the whole protein issue is really a mineral weakness really makes you shake your head.

It's also fascinating that the other two water supplements, on our old ration containing the meat and bone meal, had incredibly dramatic results, almost miraculous. Certainly if a person were using conventional rations, I have no doubt that using either of these products would solve a multitude of problems and pay for themselves many times over. But finding the crutch that fits is not as good as healing the broken leg. I think the ideal is to get completely away from the industry as much as possible, and for sure a good place to start is with meat and bone meal.

Immuno-Boost 409-830-5444

Willard's Water 800-373-5971

Fertrell 737-367-1566 *(Sea-Lac & Nutri-Balancer)*

Two weeks ago we took our second batch to the field, 1,053. We could not find one cripple or a single gimpy, weak bird. Since then, we've had several frosts and have not lost a single bird. They are clean and white, with the pinkest skin I've ever seen-wonderful color. The chicks have clean rear ends--they look almost shampooed and airbrushed instead of manure-smeared as is common. Of all the things we tried, I certainly did not expect an animal protein-less feed to work, but it has made a believer out of me. We no longer need a hospital pen. The company says this product is organic certifiable.

As of today, **this is our new broiler ration:**

Grind and Mix:

ground corn 3,250	cracked corn 2,000	roasted soybeans 3,100
crimped oats 1,100	feeding limestone 125	Nutri-balancer 300
Sea-Lac 375	kelp meal 55	Fastrack probiotic 10

We crimp the oats and crack 2,000 lbs. of the corn to add texture and increase palatability. The birds just sit and eat and eat and eat.

Here is the ingredient list for the Fertrell Nutri-balancer: Dicalcium Phosphate, Soft Rock Phosphate, Salt, Kelp Meal, Sodium Selenite, Vitamin A Supplement, Vitamin D3 Supplement, Vitamin E Supplement,Di-methionine, Choline, Menadione, d-Pantothenic acid, Niacin, Riboflavin, Pyridoxine, Thiamine, Vitamin B12, Biotin, Folic Acid, Polysaccharide Complexes of Iron, Manganese, Zinc, Copper and Cobalt.

Our current layer ration is as follows:

Grind and Mix:

ground corn 3,000	cracked corn 2,000	roasted soybeans 3,100
crimped oats 1,100	feeding limestone 500	Nutri-balancer 300
kelp meal 55		

Crimping the oats and cracking half the corn adds texture and makes the feed less powdery. This layer ration has definitely decreased old bird mortality, although production does not seem to be affected.

To really get chicks off to a good start, try feeding about one dozen boiled eggs per 300 chicks per day for the first week. Just mash them up, with shells on, and put in on newspaper or sprinkle on top of feeder This is also a way to make sure turkey poults jump up and take off. This is a great way to use pullet eggs or cracks from your egg laying operation.

Joel farms and innovates at Polyface Farms in Swoope, VA

MOBILE PENS continued from Page 3

(bolt and nut, eliminates a cross piece) to roll it. I purchased an 8'x10' blue plastic tarp which I attached over 1/2 of the top, sides, and back with cable ties. A broken lead rope (thick and easy on the hands) was tied at the bottom to the front to pull it with. Less than $50, two hours labor by one not so handy woman, and easy to handle compared to the Salatin cages. So far they have stood up to 60 mile an hour winds without tipping over. They also pulled just find behind the car attached to the bumper down to the pasture.

Even though these are great, last night while brainstorming things got even more exciting. Two hog panels, bent, cabled together, wheeled and tarped could easily rotate lambs, goats, small pigs, etc. Cattle panels (16'x 52"), set up the same way, would make ideal calf hutches at 1/4 the cost of poly domes or plywood ones. More mobility? Put wheels on the front too. No mobility? Just don't add the wheels. Lots of wind? I use an 18" length of rebar with a 6" T on top with a 4" piece welded off one side of the T for staking (we also have a cable staking system down the length of the road right-of-way here and through the yard-I prefer to use the lawn grass rather than just mow it, you can mow over the cable for a neat look).

You can also cut a door into the panels without compromising the integrity of the design and use that piece as the door itself (or a larger piece, we use pieces of cattle panels for walk-through gates-lightweight and cheap). Heavy wire can be used to bow the tarp up and give a covered wagon effect (keeps rain from puddling on the top). Buckets for water and grain can be hung off the wire or in the corners.

This basic design could be valuable on nearly any farmstead. Consider the potential for storage of the lawn tractor, rototiller, bicycles, etc. Tarp the sides and use it for a brooder pen. Wire the bottom for a rolling rabbit cage. A couple of more bends (4'x 4')and you have an ideal little shelter for goats, sheep, dogs, chickens, etc. Even a playhouse for the kids.

They last forever (galvanized), can be stacked, hung from the ceiling in the barn (remember how the oldtimers stored their cutters and wagons?), or just left outside. The tarps are lightweight, under $5, and usually last several years.

Cattle panels are great. I've seen people make greenhouses out of them. I use them bent over for a green bean trellis (a cool spot in the garden in the summer, mix in morning glories for a real treat to the eye).

Hope this is of use to someone out there!

Bev is the SE MN Sustainable Farming Assoc. Coordinator

Mustang Creek Homestead, MN

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Scavenging for Fun and Profit

Finding used equipment or materials which can be put to good use is one of the best ways to control costs and increase the profitability of your pastured poultry enterprise. It is also an excellent way to put true recycling into practice by reusing items which might otherwise end up in a landfill. I'd like for us to share ideas for creative scavenging so I'll get the ball rolling with one story of my own.

continued on Page 6 - SCAVENGE

800-346-9140

ATTRA
Appropriate Technology Transfer for Rural Areas

Processing & Marketing Chicken Products: Meat & Eggs

Livestock Production Guide

ATTRA is the national sustainable agriculture information center funded by the USDA's Rural Business -- Cooperative Service.

Contents

Small-scale poultry producers raise chickens in several different pasture-based models; however, two issues that they all share are processing and marketing of the chicken products. This publication is a companion piece to ATTRA's Sustainable Chicken Production which describes pasture-based models including free-range, pastured poultry, and the chicken tractor. ATTRA's Sustainable Egg Production discusses adapting these models for layers.

Slaughter

No matter what type of model you use to raise your poultry, small-scale producers share issues and concerns with processing.

Slaughter options for small-scale poultry operations include slaughtering on-farm, or contracting with a slaughter plant to do custom processing. Some producers have been able to make special arrangements, such as leasing a small processing plant for slaughter day.

On-farm slaughter is carried out in a variety of settings: indoor areas, open-walled shed set-ups, or completely outdoors where the sun can aid in disinfection. Some producers even mount processing equipment on a trailer to share with other farmers. Access to clean water is important and screens for fly control may be necessary.

The procedure for on-farm slaughter usually starts with withholding the feed the day before slaughter to reduce the amount of feed in the gut and the possibility of tearing the gut and causing bacterial contamination. Slaughter involves cooping the birds, transporting them to the slaughter area, placing the birds in killing cones, slitting their throats and letting them bleed out. The birds are then scalded to loosen the feathers, and the feathers are removed (usually with a mechanical plucker). The heads and feet are removed and then the carcasses are cut open and the organs removed (evisceration).

The carcasses are usually chilled down in a cold water tank. (It is important to maintain cool water for chilling—in hot areas, ice may be needed.) Slaughter of older laying hens usually takes longer, because scalding takes longer and the feathers are harder to remove. Aging chicken meat at cool temperatures just above freezing (30-32°F) tenderizes the meat—broilers should be aged for at least one day (1).

Books on poultry production describe the butchering process, especially the evisceration, in more detail. Important equipment and resources include the coops, killing cones, knives, scalder, plucker, stainless steel eviscerating tables, buckets, clean water, pans, cooling tank. Scales are needed if you sell by weight and refrigeration and bags if you do your own aging. Waste water from processing is applied to a garden, and offal can be composted or buried.

Ohio poultry farmer Herman Beck-Chenoweth (1) believes that contamination from salmonella is less during on-farm slaughter than in the industry. He believes that hand evisceration is less likely than machinery to tear the intestinal tract and spread pathogens. Also, many carcasses at once are added to chill tanks in large-scale processing plants--if one carcass is contaminated--many will be as well. Chlorine is used in large amounts to kill pathogens.

Virginia poultry producer Joel Salatin (2) has developed a successful model for producing about 8000 chickens a year on pasture and processing the birds on-farm. His book Pastured Poultry Profits (3) discusses processing in detail, including inspection considerations and photographs that show how to eviscerate. Salatin's video is also particularly useful for processing. Joel and wife Teresa's set-up includes a batch scalder and plucker that can handle at least 4 birds at a time. The Salatins can process about 50 birds per hour working together, usually processing about 300 birds on a weekend morning. Because customers come to the farm immediately after slaughter to pick up their birds, there is no need for refrigeration, bagging, or delivery. Salatin believes it is important not to try to compete with industry giants who have lower transportation and handling costs.

Another perspective on small-scale slaughter is presented in Herman Beck-Chenoweth's new book Free-Range Poultry Production and Marketing (4). Beck-Chenoweth processes about 1000 birds per year and bags the birds for the customer. Beck-Chenoweth's book also presents a design for a small-scale indoor processing facility that could possibly be state approved. He shows a set-up for Pickwick equipment that could process 200 broilers per hour and would cost about $15,000 (building cost not included).

Equipment

Several companies that sell processing equipment (new, used, homemade). Companies selling new equipment include Stromberg's (5) and Pickwick's (6).

Since poultry processing equipment is expensive, many producers buy used equipment from sources such as Tom Neuberger of South Dakota Poultry Headquarters (7). However, less and less good used equipment is available due to increasing interest in small-scale poultry production. Some producers put together home-made versions of equipment—contact ATTRA for information on home-made scalders and pluckers. Kenneth King of Jako, Inc. (8) has developed low-cost, batch scalders and pickers that sell for about $1700 each.

Mobile Processing Units (MPU) are a useful way for producers to work cooperatively on equipment cost and the intensive labor involved with processing. Kenneth King has mounted his equipment on a trailer which he shares with several other poultry farmers in his area. He shares the equipment with four other producers and they help each other on slaughter day. He estimates a similar trailer set-up using his own scalder and plucker, killing cones, eviscerating table, etc. would cost about $7000. A traveling butchering facility might be a viable business option for custom processing.

If you are not ready to invest in processing equipment, then one option is to use a large stockpot in the backyard with a fire as a scalder. Or Beck-Chenoweth suggests experimenting by purchasing a utility sink from the hardware store, a thermostat, and a water-heating element. A mechanical picker may not be needed until a lot of birds are processed because the feathers come out easily after scalding. An alternative to scalding and picking equipment is to dry pluck the feathers immediately after slaughter; however, this is a difficult process—the skin often tears.

It may be good to start out on a small-scale, build your market, and then upgrade your equipment as necessary. Many small-scale producers say that it is not difficult to resell used equipment.

There is some interest in alternative processing. When entrepreneur David Wilson (9) set up a large-scale processing plant in Kentucky, he used air chilling instead of tank cooling to cool the carcass down after processing. The birds were hung on shackles in a tunnel with super-chilled air. He believed that this method of processing maintained the superior taste of the bird since there was no water uptake by the carcass as occurs during tank cooling.

Regulations

It is important to comply with federal and local regulations for processing—the axiom "ignorance is not an excuse" applies here.

There is a 20,000 birds per year freedom-of-inspection federal law. The legislation is described in The Poultry Products Inspection Act (Section 15). The public law only applies to poultry and has such restrictions as no interstate shipping. Contact the Food Safety and Inspection Service (FSIS) Regulatory and Compliance Program in Washington, DC at 202-254-2539 for information about regulations for on-farm or small-scale processing.

Farmers intending to process on-farm should also be aware of state and local regulations. Your state department of agriculture will have information about regulations as will your health department. Many states use the federal law but others are more restrictive and only allow 1000 birds per year. A label may be required giving the address of the farm where the poultry was raised and stating if the product is not inspected. It may not be possible to sell non-inspected poultry to restaurants or stores.

Some producers decide to build their own state or federally approved plants. There are several small-scale poultry processing operations. Examples are Arnold Speth's plant near Platteville, Wisconsin processing about 40,000 birds per year (10) and the Chris Weick's plant in Umbarger, Texas processing about 8000 birds per year (11).

As a case study, when Ohio poultry producer Herman Beck-Chenoweth researched the regulations *in his part of Ohio,* he found the following (adapted from his book <u>Free-Range Poultry Production and Marketing</u>):

> <u>Level One (0–1000 birds per year):</u>
> Exempt from rules. All birds must be labeled with grower's name and address. All birds sold by the farmer must be grown and processed by the farmer. Birds can be sold to the ultimate consumer only—no third party sales such as through grocery or health food stores. Farmers' markets, on-farm sales, or delivery routes are okay.
>
> <u>Level Two (1000–19,999 birds per year):</u>
> Inspected facility required. Bird by bird inspection not required. Same sales rules as above.
>
> <u>Level three (20,000+ birds per year):</u>
> Inspection, federal or state, required for all birds processed. Only limitation is that state inspected birds cannot be shipped across state lines; federally inspected birds can be shipped all over the U.S.

Eggs

Before getting into egg sales, it is important to research your market (i.e. demand for brown vs. white eggs, pricing, etc.) Farm-fresh eggs may differ from industry eggs. Small-scale egg producers use many phrases to advertise their products: "farm-fresh," "stand tall in the pan," "rich, yellow yolks," "uncaged, free-range hens," "humanely-treated hens," "unmedicated feed," etc. Commercial eggs may be up to nine months old when sold at the grocery store to meet fluctuating market demands (1).

According to Herman Beck-Chenoweth, producers with an operation smaller than 3000 layers is exempt from federal egg inspection. However, he says you need to label your egg cartons properly, especially for sale in stores. If you are selling in re-used cartons, strike out any inaccurate information. Label the size of the egg (jumbo, extra large, large, medium, small peewee)—label "mixed-unclassified" if you mix sizes. Some stores will require a stale-date on the end of the carton.

Seasonality is an issue with farm-fresh poultry products, especially eggs. Since farm-fresh eggs are generally not stored for sale, it may be useful to devise a way to handle short-falls and excesses of eggs. Beck-Chenoweth uses a tiered system in which customers who pay the most for their eggs receive eggs year round, while those that pay less may only be sold eggs when available.

In terms of economic efficiency, Beck-Chenoweth gets $2.00 per dozen for mixed size eggs ($2.50 for jumbos). He nets 90¢ per dozen ($1.30 for jumbos). However, labor must be added in. Niche markets exist for specialty eggs. As an example is an egg high in omega-3 fatty acids, which may have beneficial affects on human health. Hens can be fed flaxseed to produce eggs with a higher contact of omega-3 fatty acids.

Refer to one of the many books available on small-scale poultry production for general information on egg management. Gail Damerow's book A Guide to Raising Chickens (12) has a useful section on egg collection, quality, safety, storage, etc. Industry-focused books such as Poultry Science (13) have useful sections on egg inspection and quality. Eggs are inspected on the basis of their external characteristics, internal (by candling), and broken out for further examination.

Marketing

Prices should be higher than conventional products because farm-fresh poultry is a specialty product and costs more to produce.

Farm-fresh poultry and eggs are alternatives to industry-raised poultry products, therefore alternative marketing channels should be considered. Chicken used to be considered a delicacy before it become so widely available. According to a Cornell taste-test study, 54% of consumers preferred range-raised chicken compared to confinement-raised chicken (14).

Pasture-based poultry producers often claim that their product is more flavorful and firm due to exercise. Most small-scale producers harvest broilers at about 8 to 9 weeks, which is older than the industry average of about 6 weeks. Older birds tend to have more flavor. Flavor is desirable by some; others prefer bland chicken. Birds also get tougher as they get older. At about 9 weeks, a chicken is not longer considered a broiler but rather a roaster. Yolks from ranging layers tend to have a deep yellow-orange color due eating plants.

Many consumers value "farm-fresh" meat products instead of industry-raised products. Some value meat and eggs that have been produced from livestock raised in more "natural" environments and without routine use of growth stimulants and drugs. Some consumers support family farms and may want to visit the farm where the meat is produced in order to get more in touch with their food supply. Children can participate in poultry production (including 4-H clubs) and may help in marketing with egg routes.

Eggs can be a good marketing tool, because they are easy to sell and may open the door for customers to buy other products such as chicken meat, produce, etc.

Direct markets

In establishing a direct market, one can start with producing poultry for family, selling to neighbors and friends and at farmers' markets. Brochures, flyers, and advertising may be useful; but giving out free samples, holding a chicken barbecue, and giving slide programs to civic groups are ways to attract customers. Advertising by newspaper and radio may reach consumers that are looking for a deal, instead of customers interested in a quality alternative product.

Direct marketing may require producers to educate consumers about the benefits of farm-raised poultry products, which can sometimes be frustrating. "Word of mouth" may create an adequate growth rate for a small operation.

Herman Beck-Chenoweth's book Free-Range Poultry Production and Marketing contains an excellent section on marketing. He stresses the importance of public relations. When a newspaper or magazine writes a story on your operation, particularly a feature article, you couldn't pay for that type of advertising.

In his book, Beck-Chenoweth discusses advertising and marketing in detail. Advertising includes newsletters, point-of-purchase information such as counter cards, posters, flyers, etc., classified ads, radio commercials, yellow pages, post cards, road signs, etc. Market outlets include direct farm sales and road side stands, farmers' markets, home delivery, restaurants, grocery stores, health food stores, caterers, buying clubs, CSA's (community supported agriculture), mail order, etc.

Beck-Chenoweth found that selling at the farmers' market required a lot of work: packing the birds in coolers, transportation to the market, set-up, sales, re-pack, return from the market, unpack. He finds restaurants and buying clubs to be a more cost-effective way to market. He found that further cutting up the carcasses into halves, skinless-boneless breast, etc. improves profitability.

In terms of economic efficiency, most small-scale producers charge at least $1.50 per pound or $6.00 for a 4-lb. carcass—some markets may pay more. Many producers aim for at least a $2.00-3.00 net per bird.

A directory of producers of "humanely-produced" animal products has been published (15)—this type of directory may function as a marketing tool for alternative producers. Ethnic markets for poultry may exist in some areas, especially for duck and geese.
ATTRA has more information on direct marketing.

Certified Organic Production

Organic and natural niche markets may also be tapped. At present, the USDA does not permit "organic" labels for livestock products, because federal standards are not yet set for organic livestock production. However, some existing private and state certifying agencies are able to provide their certification if an operation meets their criteria. The ATTRA publication Organic Certification is available upon request. In some areas, organic eggs command as much shelf space as conventionally-produced eggs.

Most programs' standards for certified livestock production require that 100% of the feed be certified organic and that no antibiotics, wormers, growth promotants or insecticides which are not on the program's list of approved natural products be used. The Organic Crop Improvement Association (OCIA) (16) dictates that for organic broiler production the animals may be purchased as one-day-old chicks and fed 100% organic feed until slaughter; layers must receive organic feed for six months before their eggs can be considered organic.

Large-scale marketing

On a large-scale, the Food Animal Concerns Trust (FACT) (17), markets "Nest Egg" brand eggs which are produced by uncaged layers on a drug-free diet. FACT sells eggs in grocery stores in the Chicago, New York, and Washington, D.C. areas.

A family-owned operation, Chino Valley Ranchers (18), markets about 20 million eggs per year under several different labels. In addition to uncaged, nonfertile eggs, they offer fertile eggs and range eggs.

Summary

Many options exist for small-scale producers to add value to chicken products and market them. On-farm processing and direct marketing are important tools. Producers need to be aware of all federal and local regulations that may apply to them.

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26328 Locust Grove Road
Creola, OH 45622
740-596-3079

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Polyface Farms, Inc.
Rt. 1, Box 281
Swoope, VA 24479
(540) 885-3590

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The Stockman Grass Farmer
P.O. Box 2300
Ridgeland, MS 39158-2300
1-800-748-9808
Book ($30 plus $4.50 s/h)
Video ($50)

4) Beck-Chenoweth, Herman. 1996. Free-Range Poultry Production and Marketing. Back Forty Books, Creola, OH. Order from:
Back Forty Books
26328 Locust Grove Road
Creola, OH 45622
740-596-3079
$39.50 (plus $4.50 s/h)

5) Stromberg's
P.O. Box 400
Pine River, MN 56474
218-587-2222

6) Pickwick
1870 McCloud Place NE
Cedar Rapids, IA 52402
319-393-7443

7) Tom Neuberger
South Dakota Poultry Headquarters
Rt. 1, Box 303
Canistota, SD 57012
605-296-3314

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Kenneth King
6003 E. Eales Rd.
Hutchinson, KS 67501
316-663-1470

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1436 Century Rd.
Auburn, KY 42206
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1001 Y Street, Suite B
Lincoln, NE 68508-1172
402-477-2323

17) Food Animals Concern Trust
P.O. Box 14599
Chicago, IL 60614
773-525-4952

18) Chino Valley Ranchers
P.O. Box 353
Chino, CA 91708
909-590-2023

**Prepared by Anne Fanatico,
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February 1998

Mobile pens of chickens on the pasture.

Ready to eviscerate!

Pastured Poultry

A Heifer Project International case study booklet

Building a mobile pen.

Laying hen.

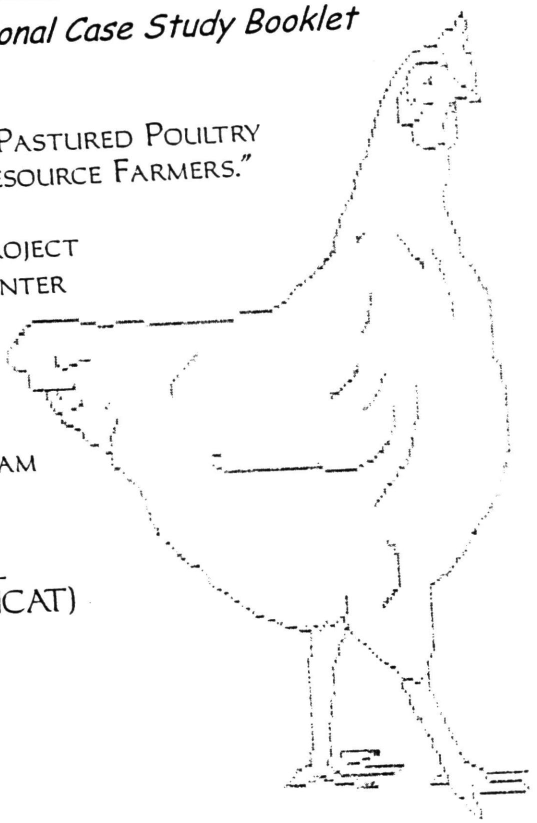
Home-grown's <u>the</u> best!

The mechanical plucker.

... Sustainable Agriculture Research & Education (SARE)

Pastured Poultry

A Heifer Project International Case Study Booklet



- A summary of the project, "Integrating Pastured Poultry into the Farming Systems of Limited Resource Farmers."
- Conducted from 1996-1999 by Heifer Project International (HPI) & the National Center for Appropriate Technology (NCAT).
- Funded by USDA's Southern Region Sustainable Agriculture Research and Education (SARE) program
- Compiled by Anne Fanatico, Program Specialist with the National Center for Appropriate Technology (NCAT)
- Published in December, 1999

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HPI is a private non-profit corporation dedicated to community development through sustainable livestock production. The headquarters is located in Little Rock, AR.

NCAT is a nonprofit organization with offices at Butte, MT, and Fayetteville, AR, which manages a host of public programs dealing with sustainable agriculture, along with energy conservation, low-income energy and housing issues, and sustainable community development. NCAT's role through its projects is to improve the economic well-being and quality of life of urban and rural residents, all the while working to improve the environment and conserve America's natural resources.

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Foreword & Acknowledgements

This booklet summarizes the experiences of 35 Southern farm families who from 1996-1999 participated in a project titled "Integrating Pastured Poultry into the Farming Systems of Limited Resource Farmers."

The experience proved favorable for 27 of the project families who continue to raise range poultry for home-use and for sale to growing customer bases.

We hope this booklet will prove useful as a decision-making guide for other farmers interested in adding diversity and improving profits in their own agricultural enterprises through pastured poultry production.

We are thankful to many people who assisted in compiling this booklet. Especially helpful were the farmer grantees who took special care to keep close records of their enterprises and share that information for the benefit of potential producers.

Other people, organizations and agencies who made special contributions to the project are the National Center for Agricultural Law Research and Information; Extension agents and staff at Tuskegee University, Southern University, Kentucky State University, South Carolina State University, Florida A&M University and Fort Valley State University; members of the American Pastured Poultry Producers Association; and the Joel Salatin family of Swoope, VA.

We thank those individuals who were so generous in sharing photographs and slides they snapped during field days, trainings and activities on their farms. Their work helps greatly to tell the pastured poultry story and appears throughout this booklet

We are also very appreciative of the four farm families in the "Featured Farmers" chapter of this booklet. We thank them for sharing both the trials and the triumphs they experienced while learning the techniques of raising, processing and marketing poultry on-farm as a way to supplement their income.

✧ *Anne Fanatico, Program Specialist, National Center for Appropriate Technology*

✧ *Skip Polson, Program Consultant, Heifer Project International*

INTRODUCTION

"PASTURED POULTRY IS A NICHE MARKET YOU CAN TAP"

Pastured poultry is a niche market in which some consumers are willing to pay more for what many of them consider to be tastier, healthier and more humanely grown chicken. The poultry industry in the U.S. was pasture based until the 1950s when confinement housing became the norm. Small, independent producers have been replaced by highly integrated companies.

Today there are many consumers interested in "natural" poultry products. Consumers have different interpretations of the term "natural" but it usually includes flocks of chickens that roam on grassy pasture and eat only non-medicated feeds that do not contain unappealing by-products. Some consumers want certified organic products or gourmet products, believing that pastured poultry delivers better nutrition and taste.

Some are motivated by nostalgia and look for that Sunday fried chicken they enjoyed on Grandma's farm. Some consumers are interested in range poultry for welfare or aesthetic reasons,

Farmer trainees place chickens in killing cones on processing day.

or because they think it is an environmentally sound way to produce poultry. Other distinctions made by consumers and retailers have to do more with processing than production. Some consumers are attracted to the

IN THIS SECTION:

- ✔ADVANTAGES OF PASTURE SYSTEMS
- ✔MAJOR ACTIVITIES OF THE PROJECT
- ✔FUTURE & COLLABORATIVE WORK

concept of on-farm processing, while others demand government inspected processing. Some consumers also make marketing distinctions. For example, they may prefer to buy direct from the farmer to support local food production and strengthen rural communities.

Features of pastured poultry model:

- Chickens in field pens moved daily to fresh pasture
- Non-medicated feed
- On-farm slaughter
- Direct marketing from the farm

Heifer Project International (HPI), a non-profit development corporation dedicated to community development through sustainable livestock production, seeks ways to help farmers find profitable, low-capital production and marketing enterprises. In April 1996, HPI was funded by the USDA's Agriculture Research and Education (SARE) program for the 3-year project, "Integration of Pastured Poultry Production into the Farming Systems of Limited Resource Farmers."

The HPI project helped limited resource farmers in the South boost incomes and diversify their operations by growing, processing and marketing chickens on their farms. The project employed the methods of Joel Salatin of Virginia, author of *Pastured Poultry Profits: Net $25,000 in 6 Months on 20 Acres*.

✔ Advantages of a pastured poultry system

In the Salatin pastured poultry model, chickens are raised in floorless field pens moved daily to fresh pasture. Seventy-five to 90 broilers are kept in each 10′ x 12′ x 2′ pen.

MOST FARMERS PRODUCING LESS THAN 1,000 BIRDS PER YEAR ARE ABLE TO SELL ALL OF THEIR PRODUCT.

The chickens receive exercise and fresh air while foraging for plants and insects, and their manure adds fertility to the pasture. They are fed a supplemental feed concentrate, usually without routine medications such as antibiotics. Feed costs are reduced by keeping birds on pasture.

Production is usually seasonal—participants order day-old chicks from early April to October from hatcheries. Chicks are brooded and moved onto pasture at about 2– 3 weeks—when they are feathered out and when weather permits.

Processing & marketing

Birds are usually slaughtered on-farm at about 8 weeks of age and customers come directly to the farm to pick up their chicken. Although marketing is usually word-of-mouth, producers put significant effort into planning sales, reminding customers of pick-up dates, and having the birds ready on time.

Although pastured poultry is a high-labor enterprise, especially for small-scale start-ups, the participants and their customers were happy with the final product and believe pastured poultry enterprises help build

✔ Future & collaborative work

A major indication of the first project is the need for government approved processing facilities especially for those producers interested in commercializing range poultry.

To meet this need, HPI began a second poultry project with support from Southern Region SARE in 1999 called "Enhancing Feasibility for Range Poultry Expansion." There is an increasing demand for range poultry — including regionally produced.

PLEASE SEE "APPENDIX 6: RESOURCES SECTION" OF THIS BOOKLET IF YOU WOULD LIKE TO ORDER A COPY OF HPI'S FINAL PROJECT REPORT.

Processing investments

In order for producers to access processing facilities, investments are needed to build independent processing plants. Currently, very few facilities exist for custom processing of poultry— integrated processing plants do not serve independent farmers. A way to spread investment risk for limited resource farmers is collaboration with other farmers and associates--a mobile processing unit (MPU) is one of the options.

The project will examine the steps needed for building an approved MPU in three states (Kentucky, Alabama, and Mississippi), as well as feasibility issues that farmers need to examine when planning a business, such as developing a marketing plan. A "feasibility toolbox" will be created as a resource for farmers. Also examined will be nutritional resources (obtaining feed in bulk, and getting nutritional advice for natural formulations.) and obtaining reliable stock.

HPI is very interested in other groups involved in range poultry as well. In a separate SARE-funded project, Southern University (project leader Jim McNitt) will be studying integration of pastured poultry with vegetable production.

Producer life issues

The University of Wisconsin (project leader Steve Stevenson) received a SARE grant in 1997 to examine the economic and quality of life issues for pastured poultry producers, as well as the nutritional qualities of pastured poultry compared to conventional poultry (fat, cholesterol, texture, flavor, microbes, and vitamins.) when processed on-farm or in government-inspected plants. They are also carrying out marketing analyses.

FEATURED FARMERS

ADVENTURES IN RAISING, PROCESSING & MARKETING POULTRY ON THE FARM

Laura & Ralph Rogers of Woodbine, KY

Providing home-raised poultry to family and neighbors and learning to hatch and sell baby chicks in the community

Laura and Ralph Rogers have been involved with Heifer Project International (HPI) projects in the past through a local group, Whitley County Small Farms Project. Operating on 9 acres, they keep cattle, goats, bees, and poultry. Their two children, Sarah and William (ages 8 and 5), have participated in farm activities and pastured poultry for the past 3 years. Ralph works off farm in electrical lighting. The Rogers were trained at the initial HPI session at the Salatin farm in June '96. Laura had previously kept chickens but was interested in learning how to butcher by herself.

FEATURED FARMERS ARE:
- ✦ LAURA & RALPH ROGERS
- ✦ ROSA & ALVIN SHAREEF
- ✦ BEN GAMBLE
- ✦ PLEN YEP

Ralph Rogers takes chickens from cages for processing.

Snapshot: Getting started:

The Rogers built a pen for the first batch of 105 chicks, which arrived on the farm on 6/27/96 and were placed in field pens 3 weeks later. A total of 17 birds were lost during production due to sudden storms and occasional crushing when moving the pen. A total of 88 birds were slaughtered at 9 and 10 weeks old on 8/29/96 and 9/5/96. Twenty-five chickens were sold at $6.00 each and 21 were given away as free samples. There were 31 customers or recipients of samples. The Rogers kept 42 birds for home consumption. They used a total of 1244 lbs. of feed or 14 lbs. per chicken. The feed cost 13 cents per lb. Their expenses and income are summarized below.

Note: For all the Featured Farmers, production numbers may not add up exactly—the only numbers available were those provided by the farmers.

Fixed Costs

	Cost before Amortization	Amortization Factor[1]	Cost after Amortization
Pen	$136.10	10 batches	$13.61
Waterer	$22.95	10 batches	$2.30

Direct Costs	
Chicks	$53.00
Hired help	$25.00
Feed	$166.58
Total Costs	$260.49
Income/Value[2] of 69 chickens @ $6.00 each	$414.00
Net	$153.51

[1]The fixed costs were amortized since it is assumed the items will be used for at least 10 batches.
[2]The value of birds kept for home consumption is included with the income. Any birds given away as free samples are not included as income—they are a marketing cost although not counted as such in this chart.

Total labor budget **84.5 hours (training time not incl.)**
Earnings per hour **$1.82/hour**

Note: For all Featured Farmers, although the initial earnings per hours are low, there is potential for improvement as producers increase in experience and scale of production.

Since beginning, Laura has raised about 6 more batches of 100 chickens each. She no longer keeps 100 birds in a pen since they are crowded when they get larger. Ralph built a second broiler pen. Now 50–75 broilers are kept in each. Ralph has modified the new pen with fiberglass on top instead of the usual aluminum. Mortality is low once the birds are on pasture, although stray dogs can be a threat. Laura moves the pens herself and the children help feed the birds. She starts raising birds in the spring and starts her last batch in August.

Laura also hatches baby chicks for sale as a separate enterprise. She has incubator equipment that can set 500 eggs at a time. She sells Golden Lace Wyandotte and Buff Orpington chicks for layer stock at 70 cents apiece. She has sold at a local stock sale in the past, but people now come to her directly.

Brooding has been troublesome for Laura. She sections off a corner of her barn with plywood and hangs heat lamps to brood chicks. More and more cracks are forming in the walls as the barn ages, creating drafts.

Hatchery chick problems

A second problem in brooding has been the quality of the broiler chicks Laura receives from mail-order hatcheries. The chicks are often damaged by the time they reach her and sometimes starving since they have exhausted their yolk sac feed reserves. The hatchery replaces them but Laura has still invested time and resources in trying to save the damaged chicks. Laura has also noticed a large range of quality with the healthy chicks she receives from hatcheries—some batches of birds perform very well; others do not.

Due to problems with ordering by mail and unreliable quality, she has decided to apply her hatching skills to broiler breeders as well as layers. She is currently applying for funding and exploring ways to hatch good quality broiler chicks on her farm and relay this technology to other farmers. She believes it is important for farmers to be able to raise their own broiler chicks in their communities.

Processing equipment

Laura slaughters the birds at about 8–9 weeks. She uses processing equipment on loan from HPI and shares it with other farmers as needed. The killing cones, scalder, and picker work well. It took some time to find a stainless steel table for evisceration. Chickens are not weighed at processing.

Laura bags the birds for a nice appearance and sells them fresh. Customers are timely in their arrival to pick up the birds. Five-year-old William has been especially helpful in catching the birds for slaughter as well as in the processing.

The Rogers enjoy keeping about half of the birds they raise and selling the other half. Son William refuses to eat chicken from the supermarket. Laura continues to sell the birds for $6.00 each. She decided on her price by what she thought people would be willing to pay.

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MARKETING ON THE ROGERS FARM IS BY WORD-OF-MOUTH, ALTHOUGH THEY HAVE ALSO ADVERTISED ON THE RADIO. LAURA COULD SELL MORE CHICKENS IF SHE RAISED MORE. SHE SEEKS INPUT FROM HER CUSTOMERS WITH A QUESTIONNAIRE. SOME COMMENTS FROM THEIR FIRST CUSTOMERS WERE: "REAL TENDER," "COOKS FAST," AND "LOVE IT."

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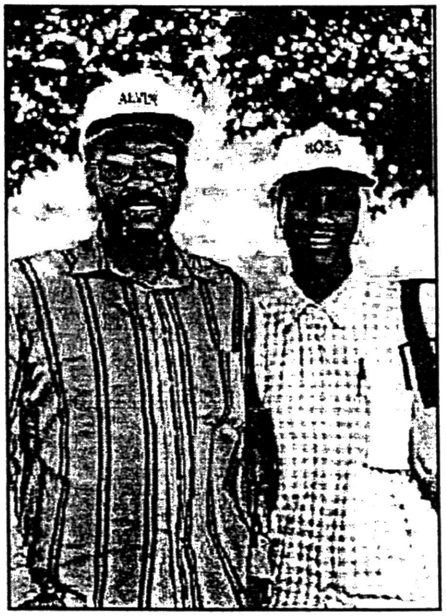
In terms of record-keeping, she keeps track of how much she pays for feed, how many birds she sells, and her income. She does not know her earnings per hour when labor is figured in but is happy with the enterprise. Manure from the chickens on pasture has increased the pasture fertility for the other livestock.

Instilling family values

On the farm, the Rogers value the opportunity to involve the whole family in hard work and shared religious values. The pastured poultry enterprise enhances these values, because the whole family has been involved. The children both know that the first thing to do every morning is move the chickens and feed all the animals.

Featured Farmers: Alvin & Rosa Shareef

Raising and processing chickens in a Muslim community and spreading the word: "We have become ambassadors for pastured poultry." Want to expand processing capability to reach out-of-state markets.



Alvin & Rosa Shareef take a break at a field day for a photo.

The Shareefs raise pastured poultry in a small Muslim community in Mississippi called New Medinah where about 10 families live. New Medinah was started in 1987 when a number of Muslims throughout the country each bought an acre of land in the area—for a total of 84 acres. Rosa and others moved there from northern cities like Chicago.

Families in New Medinah have been involved with HPI in the past through the Marion County Self-Help Organization. The families living there now graze sheep, goats, and poultry on the land. They have also tried cut flower and vegetable enterprises; however, pastured poultry forms the cornerstone of their farm operation. Rosa teaches in the community school andAlvin works off-farm. Rosa, Alvin, and Abdul Mahmoud trained at the first Salatin session in Virginia in June 1996. Rosa saw pastured poultry as an enterprise with definite potential.

<u>Snapshot: Getting started</u>

The Shareefs' first 100 chicks arrived on the farm on approximately 9/9/96. They were placed in pastured field pens 3 weeks later. A total of 6 birds were lost during production. A total of 94 were slaughtered at almost 8 weeks of age on 11/2/96. Sixty-four chickens were sold at a price of $1.40 per lb (birds weighed about 4 lbs) and 10 birds were given away as free samples. There were 21 customers and recipients of the samples. The Shareefs kept 16 processed chickens for their own eating. They used 900 lbs. of feed (10 lbs per chicken). The feed cost 18 cents per lb. Their expenses and income for the first batch of 100 birds are summarized below.

Fixed Costs	Cost before Amortization	Amortization factor[1]	Cost after amortization
Pen	$121.72	10 batches	$12.18
Brooder	$58.90	10 batches	$5.89
Processing supplies	$74.56	10 batches	$7.46
Dolly	$66.51	10 batches	$6.65
Other	$25.65	10 batches	$2.57
Direct Costs			
Chicks			$48.00
Feed			$161.90
Freezer bags			$3.70
Wood shavings			$21.40
Total Costs			$269.75
Income/ Value[2] of 70 chickens @ $4.47 each			$314.11
Net			$44.36

[1]The fixed costs were amortized since it is assumed the items will be used for at least 10 batches.
[2]The value of birds kept for home consumption is included with the income. Any birds given away as free samples are not included as income—they are a marketing cost although not counted as such in this chart.

Total labor budget	115.50 hours (training time not included)
Earnings per hour	$0.38/hour

Since then, other families in New Medinah have been involved in pastured poultry. Abdul and Hafeeza Mahmoud also raise pastured poultry and share the processing equipment with the Shareefs. Other members of the community help out with slaughter. The families in New Medinah also work with a Mennonite family who live close by and raise pastured poultry, have hatchery capabilites, and sell feed. All members of New Medinah seem happy to have access to buying a local product that is raised and slaughtered following their religious standards.

Muslim market

The market served by the Shareefs and Mahmouds is mainly a state-wide Muslim market. There is also an annual gathering and Rosa makes sure pastured poultry is on the banquet menu. However, they also market to local non-Muslim customers. They initially posted flyers on bulletin boards in the area, put articles in the local

In New Medinah, poultry's a family thing

All members of the Shareef family have their particular work niches.

Wife Rosa's job is caring for baby chicks in the brooder. She also monitors water intake in the summer months on pasture—the birds drink a lot during hot Mississippi summers!

Husband Alvin moves the pens, feeds, and waters the birds.

Son Ahmed (9) is the egg washer for the layer enterprise.

Daughter Imani (16) collects eggs and moves chicks from the brooder to the crate when it is time to put them on pasture.

Son Sabir (19) makes time in his busy college schedule to help on processing days.

Alvin's father, Abdul-Hakim Shareef, performs the killing with a special prayer for halal slaughter, and **Alvin's mother's** job for the first few years was preparing a dinner for everyone after processing.

newspapers, and acquired business cards in order to tap a specialty niche market, but now rely on word-of-mouth.

Spreading the word

The Shareefs have given many talks and slide shows during their three years of raising pastured poultry. Rosa and Alvin spoke at the Small Farmers Conference in Nashville, TN, in November 1997 and Rosa was an invited speaker at the 2nd International Conference of Women in Agriculture held in Washington, DC, in June of 1998, as was Laura Rogers.

Both the Shareefs and Mahmouds also raise layers for table eggs. They have discovered that once you have loyal customers for one product, they are often interested in buying additional products. Niche markets can also be found for specialty products such as livers, and gizzards. A local Nigerian family only wants to buy stewers—no fryers or broilers. A local Vietnamese family likes the chicken feet.

Marketing birds

They could sell many more birds, especially if they had access to a USDA-approved plant that would permit them to sell across state lines. They currently sell 3 ½ lb fryers for $5–6 each. They base their price on what customers in the area seem able to pay. Across the Louisiana state line, many people pay $7 for a premium bird—the Shareefs have been contacted by potential markets in Louisiana. Rosa writes for an international newsletter and has realized that she could have many out-of-state customers.

An initial customer comment: "These are some fine-looking birds." Rosa adds that "After caring for the chickens I thought I wouldn't be able to eat them. I got over that fast. They were tender with an exceptional taste. KFC and Popeye's have nothing on these chickens."

Slaughtering facility

The slaughtering facility is a screened-in pavilion. Rosa acquired a 13-foot stainless steel table for eviscerating for only $50 from a local restaurant. They use processing equipment on loan from HPI; however, processing one bird at a time is slow. Customers often come to watch the processing and bring their children. Family members are very strict about not allowing anyone to process if they have a cold or other illness. The Shareefs and Mahmouds generally sell fresh but some chickens are frozen for later pick-up.

Seasonal production

The Shareefs can raise pastured poultry all year round since snow rarely falls in the winter. However, they don't raise broilers during the winter since it is unpleasant to process birds with no hot water. The layers stay on pasture all year round. Broilers are put back on pasture by February--if there is a hard freeze, tarps are used over the pens for protection.

The Shareefs were fortunate to find a free source of used bell waterers from a nearby farmer. After keeping what they needed for their operation, the children cleaned up and sold extra waterers as a business venture.

The family broods chicks in a separate building. They had trouble brooding at first—10% loss was not uncommon. However, more recently mortality has been low (about 3%) for the entire rearing period.

Figuring profits

The Shareefs clear about $2-2.50 per bird in profit. They generally figure their profit for each batch. They use a Mississippi farm record book and plan to use QuickBooks in the future. They do not have an hourly calculation for return to labor.

Early problems included a dog that broke into a pen and killed all the layers, and a faulty freezer that forced the Mahmouds to discard a batch of birds.

Goodbye, city life

The Shareefs value "being away from the big cities, eating healthy food that we can grow with few chemicals, and uncrowded living conditions for the entire family." Raising pastured poultry enhanced these values because they "were able to raise a good, quality product which we and our customers liked. We were able to instill good work ethics in our children—caring for something which is dependent on us."

BOTH THE SHAREEFS AND MAHMOUDS WOULD LIKE TO MARKET 1000 BIRDS PER MONTH, AND THEIR GOAL IS TO FARM FULL TIME.

Raising pastured poultry did take time way from other things. "We were not able to travel out of town as freely as we used to without getting someone else to feed the chickens." The Shareefs believe community life in their area would be improved if more people were raising pastured poultry. "People would be eating healthier food and be working towards similar goals which would help bond the community. Also, if more of us were raising pastured poultry, we could reach a broader market and purchase feed in bulk for a cheaper price."

Featured Farmers: Ben Gamble

Bringing youth back to the community with pastured poultry

Ben Gamble lives in Flatwood, a small community near Catherine, Alabama. Flatwood Heifer Project started in 1993 with a proposal for obtaining brood cows with calves. Beef producers in Flatwood are trying to direct market the beef, processed at a nearby USDA approved plant, with a label called Down South Foods.

Ben Gamble eviscerates a broiler

Ben raises pastured poultry on his own parcel of land. Most farmers in the community own land parcels of 40 or 80 acres. Ben cooperates with several community members on the pastured poultry enterprise: George Baldwin, Gregory Eaton, and Eaton's two teenage sons Cedric and Fredric. Ben is especially interested in the youth in his community, training them in martial arts which he learned in the military and looking for ways to convince young people to return to Flatwood community to improve it. Ben also works off-farm as a substitute teacher and school bus driver. Ben and George were trained at the initial session at the Salatin farm in June '96. Ben sees pastured poultry as an enterprise with great potential for the youth.

<u>Snapshot: Getting Started:</u>

Ben and George started with a double batch of 200 chickens (in 2 pens) which arrived on the farm 6/15/96. Four weeks later, the chickens went out to pasture. Only 5 were lost during production. They slaughtered about 140 chickens at 10 weeks old on 8/23/96 and sold them to 16 different customers.

The price was $4–4.50 per chicken. They kept about 50 for layers. They kept about 25 to eat for themselves. Ben and George used 1550 lbs of feed (7.91 lbs. per chicken). The cost of feed was 13 cents per lb. Expenses and income for the first batch of 200 birds are summarized below.

Fixed Costs	Cost before Amortization	Amortization Factor[1]	Cost after amortization
Pen (2 pens)	$74.00	10 batches	$7.40
Direct Costs			
Chicks (200)			$141.50
Feed (for 200 chickens)			$200.44
Total Costs			$349.34
Income/ Value[2] of 196 chickens @ $4.25 each			$834.00
Net			$484.66 (2 batches)

[1]The fixed costs were amortized since it is assumed the items will be used for at least 10 batches.
[2]The value of birds kept for home consumption is included with the income. Any birds given away as free samples are not included as income—they are a marketing cost although not counted as such in this chart.

Total labor budget	65 hours (training time not included)
Earnings per hour	$3.73/hour/man (2 men)

Ben now continuously runs 2 Salatin-style 10'x12' pens, along with one large pen of his own design. His steel catch pen is large (18' x 12'), with chicken wire and an aluminum top. It is easy to move and, although he stocks more birds in it, they have more room. He likes to see the birds moving around and exercising in the pen.

He does not keep his cattle in the pasture with the poultry. He finds his customers prefer to see a pastoral scene of chickens grazing and believes cattle manure could mar that imagine.

Ben and Gregory Eaton brood chicks together. The brooder is a separate 12' x 12' building. They add fresh newspaper bedding every 2–3 days. They have had good success with brooding. Ben provides a medicated feed at first. He is satisfied with the quality of chicks he receives from the hatchery.

Ben processes depending on the size of bird desired by the customer, ranging from small cornish hens to large baking hens. He uses processing equipment on loan from HPI. The scalder does not heat the water sufficiently, so he uses a supplemental water heater. Processing one bird at a time is slow. Sometimes his customers help pluck the chickens.

From Ben's initial batch, his customers commented that the texture of the meat was different and very sweet. Ben thought the chicken was "finger-licking good."

Some of his older customers prefer to buy live birds. He does not weigh birds at processing because it is too time-consuming. He freezes some of the birds for customers. He raises roaster hens and turkeys for Thanksgiving. He finds that his urban customers are especially excited about the chickens.

Calculating a price

In order to calculate a price for his birds, he calculates the cost of feed needed to raise the birds and adds in a profit for himself. He is not only interested in providing a quality product to his customer and building a relationship with them, but also realizing a profit for himself.

Ben is very interested in reducing feed costs. He mixes his own feed (soybean meal, corn, and fish meal) in a large container. He believes that the birds are able to forage sufficiently to obtain other nutrients needed in the diet. The forages on his land are bahia, clover, and dallisgrass on gently sloping land. Ben also sows wild game seed for the poultry—including oats, centipede grass, and clover. The birds particularly relish clover, barley and rye.

He is careful about record-keeping. He made extra copies of the record book provided by HPI and notes the date his chicks arrive, brooder mortality, and calculates a profit for each batch. Ben pays the Eaton boys for help during processing.

Needs USDA facility

Ben is not satisfied with his current earnings. He wants to be able to process more birds at a time to reduce labor. He would like access to a USDA-approved processing facility in order to be able to sell to restaurants in the future.

The first year, he lost a lot of chickens to predators: raccoons, opossum, and foxes. Now he keeps a dog tied to a cable run near the pens to deter predators. When he moves the pens to fresh pasture, he also moves the dog.

Ben values farm life because of the high-quality, fresh vegetables and meat available and the good health it brings.