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Commercial aquaponics production and profitability: Findings from an international survey

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ABSTRACT

Aquaponics is the integration of aquaculture and hydroponics. There is expanding interest in aquaponics as a form of aquaculture that can be used to produce food closer to urban centers. Commercial aquaponics uses methods and equipment from both the hydroponics and aquaculture industries. There have been few studies of commercial-scale aquaponics production, and the purpose of this research was to document the production methods, crop and fish yields, and profitability of commercial aquaponics in the United States (US) and internationally. An online survey was used for data collection, and 257 respondents met the inclusion criteria for the study. Eighty-one percent of respondents lived in the US, and the remaining respondents were from 22 other countries. The median year that respondents had begun practicing aquaponics was 2010. A total of 538 full-time workers, 242 part-time workers, and 1720 unpaid workers or volunteers were employed at surveyed organizations. The most commonly raised aquatic animals by percent were tilapia (69%), ornamental fish (43%), catfish (25%), other aquatic animals (18%), perch (16%), bluegill (15%), trout (10%), and bass (7%). Production statistics, gross sales revenue, investments, and sales outlets for operations are reported and compared to other fields of aquaculture and agriculture. A multivariable logistic regression model was used to study which factors were associated with profitability (as a binary outcome) in the past 12 months. Several factors were significantly associated with profitability: aquaponics as the respondents' primary source of income ($p < 0.01$; Odds Ratio: 5.79; 95% Confidence Interval: 3.8–9.0), location in US Department of Agriculture plant hardiness zones 7–13 ($p < 0.01$; OR: 4.17; 95% CI: 3.2–5.5), gross sales revenue ≥$5000 ($p < 0.01$; OR: 3.58; 95% CI: 2.2–5.8), greater aquaponics knowledge ($p < 0.01$; OR: 2.37; 95% CI: 2.0–2.9), and sales of non-food products (e.g., supplies, materials, consulting services, workshops, and agrotourism) ($p = 0.028$; OR: 2.13; 95% CI: 1.1–4.2). Our survey findings provide a better understanding of the business of aquaponics, which may enhance future commercial operations.

1. Introduction

Aquaponics is the integration of aquaculture and hydroponics, a soilless system for crop production. The recirculating aquaculture research community introduced the idea of aquaponics in the mid-1970s (Lewis et al., 1978; Naegel, 1977; Sneed et al., 1975). In their studies, edible plants were used to remove waste products from recirculating aquaculture systems. Today, commercial aquaponics production exists primarily in controlled environments, such as greenhouses or outdoor locations with favorable climates, using methods and equipment that draw from both the hydroponics and aquaculture industries.

A handful of studies have documented the productivity of research-scale aquaponics operations (Rakocy, 2012; Rakocy et al., 2006; Watten and Busch, 1984), and in 2013 the United States Department of Agriculture (USDA) began collecting aquaponics production data as part of the Census of Aquaculture, which was last published in 2006 (USDA, 2006). Results from research facilities and other factors, such as expanding interest in sustainable agriculture and producing food closer to urban centers, have stimulated interest and involvement from a small but growing aquaponics industry. However, little research has been conducted on commercial-scale aquaponics production. The purpose of

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this study was to document the production methods, crop and fish yields, and profitability of commercial aquaponics in the United States (US) and internationally.

2. Materials and methods

2.1. Survey

We created and implemented an online survey as previously described (Love et al., 2014). The study was reviewed by Johns Hopkins University School of Public Health Institutional Review Board (IRB No: 00005088).

We collected 1084 complete responses between June 25, 2013 and October 1, 2013. Summary findings from the total survey population (which mostly included hobbist gardeners, but also included educators, non-profit organization staff and commercial operators) were published elsewhere (Love et al., 2014). Survey respondents who sold aquaponics-related food or non-food products and services in the previous 12 months were administered additional survey questions; the data collected during this sub-survey are reported here.

2.2. Data analysis

Data from the survey software (Qualtrics, Provo, UT, USA) were exported and analyzed in Excel (Microsoft, Redmond, WA, USA), STATA (StataCorp, College Station, TX, USA) and Prism (v5, GraphPad, La Jolla, CA, USA). T-tests were used to compare the means of two groups by factors such as farm size and aquaculture system volume. A Kruskal–Wallis test was used to compare groups of three or more when the data was not normally distributed, and a Dunn multiple comparison post-test was used for intergroup comparisons.

In addition, a multivariable logistic regression model was used to identify factors that were associated with profitability, using profitability in the past 12 months as the binary outcome. These regression models controlled for potential within-cluster correlation by estimating robust standard errors that clustered respondents by country groups. These groups were defined as follows: 1) US and Canada, 2) Latin America (including Mexico) and the Caribbean, 3) Asia, 4) Australia and New Zealand, 5) Europe, and 6) Africa.

3. Results and discussion

3.1. Survey responses and frame

Two hundred and fifty-seven respondents met the inclusion criteria for the study. Ninety-five respondents sold only aquaponics-grown fish or plants, 69 respondents sold only aquaponics-related materials or services, and 93 respondents sold both aquaponics-grown fish or plants and aquaponics-related materials or services. A total of 188 respondents sold aquaponics-grown fish or plants, which we refer to as "commercial producers." A total of 162 respondents sold aquaponics-related materials or services, which could include the sale of supplies and equipment, consulting fees for design or construction of aquaponics facilities, and fees associated with workshops, classes, public speaking, or agro-tourism.

3.2. Demographics

Demographics from respondents are presented in Table 1. Respondents ranged in age from 18 to 72 years of age, and the mean age was 47 ± 13 years old. Most respondents were male (77%). Most survey participants (93%) had more than a high school level of education, and over a quarter of respondents (27%) had a graduate degree. The median year that respondents had begun practicing aquaponics was 2010. Less than 10% of respondents had practiced aquaponics for 10 or more years. These findings indicate that commercial aquaponics is a growing field, yet there may be a collective lack of experience among producers.

The majority of respondents (81%; n = 198) lived in the US, which was expected since the survey was in English and originated from

Table 1
Demographics of survey respondents engaged commerce.

Demographics	Number of respondents (%)			
	Total	Sold both	Sold fish or plants only	Sold materials or services only
Overall	257	93	95	69
Gender				
Male	199 (77)	75 (81)	68 (72)	56 (81)
Female	50 (19)	16 (17)	24 (25)	10 (15)
Not specified	8 (3)	2 (2)	3 (3)	3 (4)
Age, yr				
18–29	36 (14)	21 (23)	7 (7)	8 (12)
30–39	39 (15)	16 (17)	12 (13)	11 (16)
40–49	54 (21)	17 (18)	20 (21)	17 (25)
50–59	81 (32)	26 (28)	34 (36)	21 (30)
60–69	36 (14)	8 (9)	18 (19)	10 (15)
70+	11 (4)	5 (5)	4 (4)	2 (3)
Education				
Graduate degree	67 (27)	22 (24)	31 (33)	14 (21)
College degree or college classes	168 (66)	64 (70)	55 (59)	49 (72)
High school, GED, or some high school	18 (7)	6 (6)	7 (8)	5 (7)
Country				
United States	196 (81)	73 (82)	72 (82)	51 (77)
Role in organization				
Owner or operator	92 (33)	41 (44)	31 (33)	20 (29)
CEO	18 (7)	6 (7)	7 (7)	5 (7)
Executive director	15 (5)	7 (8)	5 (5)	3 (4)
School official	5 (2)	3 (3)	2 (2)	–
Farm manager	38 (14)	19 (20)	18 (19)	1 (2)
Educator	40 (14)	18 (19)	15 (16)	7 (10)
Employee	18 (7)	6 (7)	9 (10)	3 (4)
Consultant	28 (10)	15 (16)	8 (8)	5 (7)
Volunteer	11 (4)	2 (2)	8 (8)	1 (2)
Other	12 (4)	3 (3)	5 (5)	4 (6)