Dry matter, ash and elemental composition of farm-cultured black tiger prawn *Penaeus monodon*

FRANCISCO GOMES AND CLAUDE E. BOYD[1]

Knowledge of the body composition of animals and plants is necessary in making calculations of the efficiency of fertilizers and feeds in agriculture, for studying the fate of nutrients in agricultural ecosystems and for estimating pollution loads from culture units. There is currently much interest in the water pollution potential of pond aquaculture, and data on the whole body composition of culture species are needed to estimate how much of the nutrients applied in fertilizers and feeds are removed in aquatic animals at harvest. Data on the body composition of several species of fish and two species of shrimp (*Penaeus vannamei* and *P. stylirostris*) are available (Goodyear and Boyd 1972, Davis and Boyd 1978, Boyd 1985, Boyd and Teichert-Coddington 1995, Boyd and Green 1998).

The purpose of this study was to assess the elemental composition of black tiger prawn (*Penaeus monodon*), a widely cultivated shrimp species in tropical countries bordering the Pacific and Indian Oceans. Elements of primary concern were nitrogen and phosphorus, but other nutrient and non-nutrient elements were included in the analyses.

Shrimp were collected from production ponds at a shrimp farm in Madagascar. Shrimp stocking densities at this farm ranged from 8 to 10/m^2. Pelleted feed containing 38 percent crude protein was provided to shrimp. Mechanical aeration was not used except in emergencies with low dissolved oxygen, and water exchange was employed. Shrimp usually were harvested at 28 to 32 g body weight. Production methods were typical for semi-intensive shrimp culture.

Samples representing different sizes of shrimp were obtained from several ponds by aid of a cast net. Live weight and body length ranges were 2.07 to 40.32 g and 6.5 to 18 cm. Each sample consisted of approximately 150 g of live shrimp and contained from four to about 150 shrimp of similar length (±0.5 cm total length). Shrimp were washed in pond water to remove sediment particles and in tap water to remove salt from the body surfaces. Total live weight of each sample was determined by adding shrimp to a tared beaker of water and determining the weight increases to the nearest 0.01 g. Average live weights of individual shrimp in each sample were computed, shrimp were killed by chilling in ice water, and samples were dried to constant weight in a forced-dry oven at 102 C. After cooling in a desiccator, samples were weighted to the nearest 0.01 g and percentage dry weight was calculated. Dry samples were put in plastic bags and transported to Auburn University for analysis.

Samples were pulverized with a porcelain mortar and pestle, dried again to constant weight at 102 C, put in capped, plastic tubes and stored in a desiccator. Carbon and nitrogen analyses were made with a LECO Carbon-Hydrogen-Nitrogen Analyzer CHN 600 and sulfur measurements were made by incinerating samples in a LECO Induction Furnace HP10 and titrating the liberated sulfur with standard KIO_3 using a LECO sulfur titrator[2]. Aliquots of samples were incinerated at 500 C for 8 hours and the ash content measured by weighing. A double acid solution was prepared by mixing equal volumes of 1.00 N nitric acid and 1.00 N hydrochloric acid. Five milliliters of this solution were added to the ash, the mixture was rubbed with a rubber policeman and held on a hot plate until nearly dry. The residue was dissolved in double acid solution, transferred to a 100 ml volumetric flask, and diluted to volume with double acid solution. The contents of the volumetric flask were filtered through a Whatman Number 42, acid-washed filter paper. Concentrations of phosphorus, calcium, magnesium, potassium, sodium, iron, manganese, zinc, copper, aluminum, boron, molybdenum, barium, cobalt, chromium and lead in the solutions were determined with a Jarrel-Ash ICAP 9000 Plasma Spectrophotometer[3]. Concentrations of elements in dry shrimp tissue were calculated from the amounts of each element in the solutions.

Simple linear regression analyses of concentrations of dry matter, ash and individual elements (dependent variables) versus independent variables of individual live body weight and total length were made (Table 1). Many of the regressions had significant correlation coefficients (r), but the correlations were too low for the regression equations to be of much predictive value. Also, the variables of major interest: dry weight, ash, carbon, nitrogen and phosphorus were not correlated with either length or weight. Thus, the data for the 27 samples were averaged to provide the body composition (Table 2). The samples of *P. monodon* had an average dry weight of 27.1 percent which is similar to that reported for *P. vannamei* and *stylirostris* (Boyd and Teichert-Coddington 1995) and for channel catfish and tilapia (Boyd 1985, Boyd and Green 1998). The dry matter is about 80 percent organic material because the ash content averaged 19.7 percent. Concentrations of carbon, nitrogen, sulfur, calcium, magnesium, manganese and zinc in *P. monodon* were almost identical with concentrations

Table 1. Correlation coefficients (r)[1] between body weight[2], and body length[3] and concentrations of dry weight, ash, and elements in 27 samples of farm-reared *Penaeus monodon* from Madagascar.

Dependent Variable	**Weight**	**Length**	**Dependent variable**	**Weight**	**Length**
Dry weight	ns[4]	ns	Manganese	-0.71	-0.69
Ash	ns	ns	Zinc	0.64	0.63
Carbon	ns	ns	Copper	ns	ns
Nitrogen	ns	ns	Aluminum	-0.62	-0.73
Phosphorus	ns	ns	Boron	-0.54	-0.65
Sulfur	ns	ns	Molybdenum	-0.57	-0.57
Calcium	ns	-0.39	Barium	-0.62	-0.72
Magnesium	-0.42	-0.47	Cobalt	ns	ns
Potassium	ns	-0.46	Chromium	ns	-0.40
Sodium	-0.52	-0.69	Lead	ns	ns
Iron	-0.57	-0.70			

[1]Only correlation coefficients significant at P=0.05 are listed
[2]Body weight range = 2.07g to 40.32 g.
[3]Body length range = 6.49 cm to 17.96 cm.
[4]ns = not significant at P = 0.05.

of those elements reported by Boyd and Teichert-Coddington (1995) for *P. vannamei* and *P._stylirostis*. The concentration of phosphorus (0.96 percent) in *P. monodon* was less than in *P. vannamei* (1.25 percent) and *P. stylirostris* (1.22 percent). Sodium concentration was about 0.40 percent in *P. vannamei* and *P. stylirostris*, but *P. monodon* contained 0.94 percent sodium. Concentrations of iron, manganese, zinc and copper for *P. monodon* (Table 2) were similar to values for these elements reported by Boyd and Teichert-Coddington (1995) for *P. vannamei* and *P. stylirostris*.

Concentrations of boron, molybdenum, barium, and cobalt, chromium and lead were low, but the aluminum concentration of 644 ppm appears quite high. Shrimp often have accumulations of sediment under gill covers and this could be the source of aluminum, inasmuch as soils in the area contain large amounts of aluminum oxide. No data are available on the concentration of these non-nutritive elements in *P. vannamei* and *P. stylirostris*.

To illustrate how the body composition data can be used, the amount of feed nitrogen and phosphorus recovered in *P. monodon* at harvest will be estimated for the shrimp farm in Madagascar. The feed typically contains 38 percent crude protein (6.08 percent N) and 1.67 percent phosphorus. The feed conversion ratio (feed applied/shrimp harvested) averages 1.8 for the farm. Thus, 1,800 kg of feed are used to produce 1,000 kg of shrimp. The feed will contain 109.4 kg N (1,800 kg feed ´ 0.0608 kg N/kg feed) and 30.1 kg P (1,800 kg feed ´ 0.0167 kg P/kg feed). One ton of shrimp will contain 271 kg dry matter (1,000 kg live shrimp ´ 0.271 kg dry matter/kg live shrimp). The dry matter contains 11.4 percent nitrogen and 0.96 percent phosphorus. Thus, one ton of live shrimp will contain 30.9 kg nitrogen (271 ´ 0.114) and 2.6 kg phosphorus (271 ´ 0.0096). The recovery of nitrogen and phosphorus in shrimp at harvest will be 28.2 percent and 8.6 percent of the amounts of nitrogen and phosphorus applied to ponds in feed.

Boyd and Teichert-Coddington (1995) estimated that 45.3 percent of nitrogen and 21.3 percent of phosphorus applied to ponds in feed was recovered in *P. vannamei* in low-intensity culture in Honduras. It should be noted that the ponds in Honduras were stocked at low density and the feed contained only 3.47 percent nitrogen and 0.82 percent phosphorus. Production was around 500 kg/ha /crop as compared to about 1,800 kg/ha /crop for ponds of the present study. In fish culture, it is common to recover 25 to 35 percent of both feed nitrogen and phosphorus in fish at harvest (Boyd 1985). The recovery of feed phosphorus in shrimp at harvest is much lower for shrimp than for fish; because fish have bone that is comprised mainly of calcium phosphate and therefore contains much more phosphorus in their bodies (2 to 4 percent of dry weight) than shrimp.

Differences in amounts of nitrogen, phosphorus and other nutrients applied to ponds in feed and not harvested in shrimp do not represent the pollution load in pond effluents. Much of the nitrogen is lost through ammonia volatilization and denitrification or retained in organic matter deposited in sediment (Gross *et al*. 1999). A considerable amount of phosphorus is precipitated in brackishwater ponds as calcium phosphate and bottom soils absorb large amounts of phosphorus (Boyd 1995). Several other nutrients and non-nutrient elements also can be converted to insoluble forms in sediment.

Notes

[1]Department of Fisheries and Allied Aquacultures, Auburn University, Alabama 36849 USA

[2]LECO Corporation, Saint Joseph, Michigan.

[3]Jarrel-Ash Corporation, Franklin, Massachusetts.

Table 2. Mean concentrations and standard errors (SE) for dry weight, ash, and element composition of farm-reared *Penaeus monodon* from Madagascar. Entries are based on 27 samples of shrimp ranging from 2.07 g to 40.32 g in live weight.

Variable	Mean ± SE	Variable	Mean ± SE
Dry weight (% fw)[1]	27.1 ± 12.49	Iron (ppm dw)	307 ± 126
Ash (% dw)[2]	19.7 ± 4.14	Manganese (ppm dw)	23 ± 9
Carbon (% dw)	45.9 ± 2.27	Zinc (ppm dw)	80 ± 11
Nitrogen (% dw)	11.4 ± 0.42	Copper (ppm dw)	62 ± 29
Phosphorus (% dw)	0.96 ± 0.092	Aluminum (ppm dw)	644 ± 295
Sulfur (% dw)	0.69 ± 0.061	Boron (ppm dw)	6.5 ± 1.51
Calcium (% dw)	3.29 ± 0.584	Molybdenum (ppm dw)	0.7 ± 0.49
Magnesium (% dw)	0.30 ± 0.039	Barium (ppm dw)	16 ± 6
Potassium (% dw)	1.06 ± 0.131	Cobalt (ppm dw)	0.2 ± 0.44
Sodium (% dw)	0.94 ± 0.173	Chromium (ppm dw)	10.2 ± 2.98
		Lead (ppm dw)	1.7 ± 3.97

[1]fw = fresh weight.
[2]dw = dry weight

References

Boyd, C. E. 1985. Chemical budgets for channel catfish ponds. Transactions of the American Fisheries Society 114:291-298.

Boyd, C. E. 1995. Sediment, bottom soils, and pond aquaculture. Chapman and Hall, New York, USA.

Boyd, C. E. and D. Teichert-Coddington. 1995. Dry matter, ash, and elemental composition of pond-cultured *Penaeus vannamei* and *P. stylirostis*. Journal of the World Aquaculture Society 26:88-92.

Boyd, C. E. and B. Green. 1998. Dry matter, ash, and elemental composition of pond-cultured tilapia (*Oreochromis aureus* and *O. niloticus*). Journal of the World Aquaculture Society 29:125-128.

Davis, J. A. and C. E. Boyd. 1978. Concentrations of selected elements and ash in bluegill (*Lepomis macrochirus*) and certain other freshwater fish. Transactions of the American Fisheries Society 107:862-867.

Goodyear, C. P. and C. E. Boyd. 1972. Elemental composition of largemouth bass (*Micropterus salmoides*). Transactions of the American Fisheries Society 101:545-547.

Gross, A., C. E. Boyd and C. W. Wood. 1999. Ammonia volatilization from freshwater ponds. Journal of Environmental Quality 28:793-797.

World Sturgeon Conservation Society announces formation

Members of the World Aquaculture Society may be interested in the World Sturgeon Conservation Society, which was formed earlier this year. The purpose of the society is "to act as an international forum of scientific discussion for all persons interested in pertinent issues on sturgeons…." The society is dedicated to "effective conservation and management of the highly endangered sturgeon species." Included in the topics that would be concentrated upon in terms of information exchange are stock enhancement and aquaculture. Various levels of membership are available at nominal dues rates. The Journal of Applied Ichthyology has become the official publication of the society.

The President of the society and Foundational Committee Chair is Harald Rosenthal, a name well known to WAS members. Serge Doroshev, internationally known sturgeon researcher is Vice President and Foundation Committee member. Eleven other distinguished individuals fill out the society's board of directors.

Additional information on all aspects of the society can be obtained from the Home Office, World Sturgeon Conservation Society, Schifferstrasse 48, D-21629 Neu Wulmstorf, Germany. Tel: +49-40-700-6514; Fax: +49-40-70102-676.