THE EFFECTS OF VARYING PROTEIN LEVELS ON THE GROWTH, SURVIVAL AND YIELD OF *PENAEUS INDICUS* UNDER IRANIAN CONDITION

ABDULHAMID YAZDANI JAHROMI

FPSS 1995 3
THE EFFECTS OF VARYING PROTEIN LEVELS ON THE GROWTH, SURVIVAL AND YIELD OF PENAEUS INDICUS UNDER IRANIAN CONDITION

ABDULHAMID YAZDANI JAHROMI

Master of Science
Universiti Pertanian Malaysia
1995
THE EFFECTS OF VARYING PROTEIN LEVELS ON THE GROWTH, SURVIVAL AND YIELD OF *PENAEUS INDICUS* UNDER IRANIAN CONDITION

By

ABDULHAMID YAZDANI JAHROMI

Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Science in the Faculty of Fisheries and Marine Science, Universiti Pertanian Malaysia

July 1995
ACKNOWLEDGMENTS

My thanks to God who settled the seeking of knowledge as the distinctive characteristic between man and other creatures. Thanks God who has given me the opportunity to contribute knowledge to my people.

First, I would like thank the individuals who helped me to continue my M.S studies, namely, the minister of Jehad Sazandegi, Deputy and Head of Iranian Fisheries Co., Mr. Lahijanian, the Deputy Head Research and Training of Jihad Sazandegi, and the Director of Iran Fisheries Research and Training Organization. I am grateful to all of them who supported me during my study period, both materially and intellectually.

I would also like to extend my most sincere gratitude and deep appreciation to Dr. Che Roos Bin Saad who provided me with invaluable guidance, objective criticism and encouragement throughout the course of the study. I am also indebted to the members of my supervisory committee, Prof Ang Kok Jee, Dr. Hossin Emadi and Mr. Aizam Zainal Abidin, for their constructive suggestions.

I would also like to extend my appreciation to Mr. Mahdavi, Head of Hormozgan Shilat and his staff especially the Kolahi station staff who assist me in settling up the culture facility and running part of my project. I am also grateful to Mr. Hossineizaddah, Head of Oman Sea Fisheries Research Centre and his staff especially the Lab nutrition staff for helping me in the feed analyses.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Background of Study</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Statement of the Problem</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Significance of Study</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Objectives</td>
<td>7</td>
</tr>
<tr>
<td>II</td>
<td>LITERATURE REVIEW</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Protein Requirement for Fish</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Protein and Energy Requirement for Penaeid Shrimps</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Optimum Dietary Protein and Energy Requirement for <em>P. indicus</em></td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Linear Programming</td>
<td>18</td>
</tr>
<tr>
<td>III</td>
<td>MATERIALS AND METHODS</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Proximate Analysis</td>
<td>20</td>
</tr>
</tbody>
</table>

ACKNOWLEDGMENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ABSTRACT

ABSTRAK

CHAPTER

I INTRODUCTION

- Background of Study
- Statement of the Problem
- Significance of Study
- Objectives

II LITERATURE REVIEW

- Protein Requirement for Fish
- Protein and Energy Requirement for Penaeid Shrimps
- Optimum Dietary Protein and Energy Requirement for *P. indicus*
- Linear Programming

III MATERIALS AND METHODS

- Proximate Analysis
Crude Protein 20

Lipid 21

Moisture 21

Ash 22

Crude Fibre 22

Nitrogen-Free Extract 23

Carbohydrate 23

Calcium 24

Phosphorus 25

Gross Energy 29

Linear Programming 30

Preparation of Test Diets 35

Pellet Stability 37

Prawn Maintenance 37

Study Area 37

Concrete Experimental Tanks 39

Biological Filters 43

Pond Treatment 43

Feeding Rate 44

Nutritional Parameters 45

Physical and Chemical Properties 45

Dissolved Oxygen 45
Temperature 45
Salinity 46
pH 46
Ammonium Ion 46
Length and Weight Measurements 47
Statistical Analysis 47

IV RESULTS 50

Proximate Analyses of Feed Ingredients and Body of P. indicus 50
Diet Formulation 52
Quality of Pellets 55
Water Quality in Tanks and Pond 55
Growth Response of P. indicus 59
Pond Treatment 68
Body Composition 68
Economics and Net Profit 69

V DISCUSSION 75

The Use of Linear Programming in Least-Cost Formulation of Feed for P. indicus 75
Comparison of Growth Responses of P. indicus in Tanks and Pond 77
Survival Rate 78
Final Mean Body Weight 78
Final Mean Body length

Feed Consumption

Feed Conversion Ratio (FCR)

Weight Gain

Growth Rate (cm/month)

Protein Efficiency Ratio (PER)

Yield

Protein and Fat Deposition in Body of P. indicus

Profit of Cultured P. indicus Fed with Varying Protein Levels in Feeds

VI SUMMARY AND CONCLUSION

Further Studies

BIBLIOGRAPHY

APPENDICES

A Optimal Solution of the Feed with 30% Protein Content

B Optimal Solution of the Feed with 35% Protein Content

C Optimal Solution of the Feed with 40% Protein Content

D Optimal Solution of the Feed with 45% Protein Content

E Concentration of Ammonium Ion (ppm)

VITAE
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Recommended Protein and Lipid Levels in Commercial Shrimp Feeds</td>
<td>4</td>
</tr>
<tr>
<td>2  The Locally Available Raw Feed Ingredients in Iran</td>
<td>5</td>
</tr>
<tr>
<td>3  Complete Mineral Premix for Shrimp</td>
<td>34</td>
</tr>
<tr>
<td>4  Multivitamin Supplement for Prawn in Compound Feed</td>
<td>34</td>
</tr>
<tr>
<td>5  Composition of Feed Ingredients with Variable Protein</td>
<td>36</td>
</tr>
<tr>
<td>6  Physical Characteristics for Shrimp Feed</td>
<td>36</td>
</tr>
<tr>
<td>7  Description of Experimental Tanks</td>
<td>43</td>
</tr>
<tr>
<td>8  Daily Feeding Rates and Schedule for Shrimp of Various Sizes</td>
<td>44</td>
</tr>
<tr>
<td>9  Proximate Composition Ingredients Used in Four Formulated Test Diets</td>
<td>50</td>
</tr>
<tr>
<td>10 Proximate Analyses of the Whole Body of Wild Shrimp, <em>P. indicus</em> (wet basis)</td>
<td>51</td>
</tr>
<tr>
<td>11 Percentage of Amino Acids in Whole Tissue of Wild Shrimp, <em>P. indicus</em></td>
<td>52</td>
</tr>
<tr>
<td>12 Amino Acid Content of Experimental Diets from Linear Programming and Constraint Values</td>
<td>53</td>
</tr>
<tr>
<td>13 Optimal Solution for the Formulation of Feed with Varying Levels of Protein</td>
<td>54</td>
</tr>
<tr>
<td>14 Proximate Composition of Six Experimental Diets Fed to <em>P. indicus</em></td>
<td>56</td>
</tr>
<tr>
<td>15 Water Quality Data in Pond and Tanks</td>
<td>57</td>
</tr>
<tr>
<td>16 FCR, PER, SVR, Weight Gain, Feed Consumption and Yields of <em>P. indicus</em> Fed With Experimental Diets after 115-Day Culture Period in Tanks and Pond</td>
<td>60</td>
</tr>
</tbody>
</table>
17 Comparison of FCR, PER, SVR, Weight Gain, Feed Consumption and Yield of *P. indicus* Fed Experimental Diets after 115-Day Culture Period (for both Tanks and Pond) 61

18 Comparison of Number of Harvested Shrimp, Growth rate, Final Weight, Final Length, Protein and Fat Deposition and Net Profit of *P. indicus* Fed Experimental Diets after 115-Day Culture Period (for both Tanks and Pond) 62

19 Feed Consumption, Number of Harvested Shrimp, Crop and Net Profit per ha of *P. indicus* in Tanks and Pond after 115-Day Culture Period 63

20 Weight Gain, PER, FCR and Survival Rate of *P. indicus* in Tanks and Pond after 115-Day Culture Period 64

21 Final Length, Final Weight and Growth Rate of *P. indicus* in Tanks and Pond after 115-Day Culture Period 65

22 Proximate Composition of Body of *P. indicus* Fed Test Diets (dry basis) 69

23 Comparison of Partial Budget Analysis of *P. indicus* Production at Four Protein Variable Feeds and Two Commercial Feeds in a One Hectare Tank and Pond per 115-Day Cycle 70

24 Comparison of Partial Analysis of *P. indicus* Production at Four Protein Variable Feeds and Two Commercial Feeds in a One Hectare Tank per 115-Day Cycle 71

25 Comparison of Partial Analysis of *P. indicus* Production at Four Protein Variable Feeds and Two Commercial Feeds in a One Hectare Pond per 115-Day Cycle 72
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Map of the Islamic Republic of Iran Showing Study Area and Distribution of <em>P. indicus</em> in the Persian Gulf and Oman Sea</td>
<td>38</td>
</tr>
<tr>
<td>2</td>
<td>Map of Tanks Recirculation System and Pond Layout in Colahi Station</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>Water Quality Parameters in the Tanks and Pond</td>
<td>58</td>
</tr>
<tr>
<td>4</td>
<td>Weight Gain of <em>P. indicus</em> Fed Different Test Diets during the 115-Day Culture Period</td>
<td>66</td>
</tr>
<tr>
<td>5</td>
<td>Length increments of <em>P. indicus</em> Fed Different Test Diets during the 115-Day Culture Period</td>
<td>67</td>
</tr>
<tr>
<td>6</td>
<td>The Feed Cost, Profit and Income of Cultured Shrimps per 115-Day Cycle</td>
<td>73</td>
</tr>
<tr>
<td>7</td>
<td>Standard Curve for Ammonium Ion (ppm)</td>
<td>115</td>
</tr>
</tbody>
</table>
### LIST OF PLATES

<table>
<thead>
<tr>
<th>Plate</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kjedahl Auto Analyzer Mettler 0170 Titrator</td>
<td>26</td>
</tr>
<tr>
<td>2</td>
<td>Analytical Balance Used for Proximate Analyses of Feed and Feed Ingredients</td>
<td>26</td>
</tr>
<tr>
<td>3</td>
<td>Muffle Furnace Used for Determination of Ash and Fibre</td>
<td>27</td>
</tr>
<tr>
<td>4</td>
<td>Fibertec System 1010 Heat Extractor (Tecator)</td>
<td>27</td>
</tr>
<tr>
<td>5</td>
<td>Autotitrator Model Mehrzwachmacher Fribulator MZ 2000-Fria Used for the Determination of Calcium</td>
<td>28</td>
</tr>
<tr>
<td>6</td>
<td>UV-Visible Spectrophotometer Used for the Determination of Phosphorus</td>
<td>28</td>
</tr>
<tr>
<td>7</td>
<td>Biological Filter</td>
<td>41</td>
</tr>
<tr>
<td>8</td>
<td>Concrete Tanks and Biological Filter</td>
<td>41</td>
</tr>
<tr>
<td>9</td>
<td>Concrete Experimental Tanks</td>
<td>42</td>
</tr>
<tr>
<td>10</td>
<td>Earthen Experimental Pond</td>
<td>42</td>
</tr>
<tr>
<td>11</td>
<td>Scharfen Mixer Machine Used for Feed Preparation</td>
<td>48</td>
</tr>
<tr>
<td>12</td>
<td>Mincing Machine Used for Feed Pelleting</td>
<td>48</td>
</tr>
<tr>
<td>13</td>
<td>Water Quality Measurement Equipments</td>
<td>49</td>
</tr>
<tr>
<td>14</td>
<td>Cast Net Used for Sampling of Shrimp From the Pond</td>
<td>49</td>
</tr>
<tr>
<td>15</td>
<td>Dr Che Ross Saad the Supervisor Shwon Checking the Experiment in Iran (Fourth from Left)</td>
<td>73</td>
</tr>
<tr>
<td>16</td>
<td>Harvested Shrimp, <em>P. indicus</em></td>
<td>73</td>
</tr>
</tbody>
</table>
THE EFFECTS OF VARYING PROTEIN LEVELS ON THE GROWTH, SURVIVAL AND YIELD OF *PENAEUS INDICUS* UNDER IRANIAN CONDITION

By

ABDUL HAMID YAZDANI JAHROMI

July 1995

Chairman Dr Che Roos Saad

Faculty Fisheries and Marine Science

Four shrimp diets for *Penaeus indicus* were formulated using available indigenous feed ingredients (fish meal, shrimp meal, soybean meal, wheat flour, corn flour and corn oil) using linear programming techniques. All the diets were isocaloric (400 kcal/100g), containing 5 to 11.5% fat. The dietary protein levels were 30, 35, 40 and 45% with an amino acid profile similar to that of the prawn. The production costs of the diets were Rials 1140, Rials 1240, Rials 1340, Rials 1440 per kilogram respectively.

Eighteen indoor concrete tanks (3.45 m² each) receiving flow-through seawater (42 ppt) of 2 l/sec were stocked with 138 *P. indicus* fry (0.014 g mean wt) at a stocking density of 40 shrimp per m². In the case of the pond, eighteen compartments (9.5 m² each) separated by nylon nets in pond were also prepared and stocked with 380 shrimps of the same size and stocking density as the tank experiment. The shrimps were fed with the prepared diets and two commercial diets as a control for growth, feed and protein utilisation, and carcass composition during grow-out for 115 days. Specific growth rate (SGR) was high for all diets with a mean ranging from 3.02 to 3.18 with the exception of a commercial feed (Chinah) which had a value of 0.81. There were no significant differences (P>0.05) among
Significant differences ($P < 0.05$) were observed in shrimp fed 40% protein diet for net profit, yield, survival rate and weight gain as compared to shrimp fed the other diets. The results also indicate that shrimp *P. indicus* can be reared in sea water of high salinity from fry through marketable sizes more economically on an optimum dietary protein of 40%
Abstrak tesis yang dikemukakan kepada Senat Universiti Pertanian Malaysia sebagai memenuhi sebahagian dari keperluan untuk Ijazah Master Sains.

KESAN PENGGUNAAN PROTEIN YANG BERBEZA KE ATAS PERTUMBUHAN, KEMANDIRIAN DAN HASIL *PENEAUS INDICUS* DI IRAN

Oleh

**ABDUL HAMID YAZDANI JAHROMI**

Julai 1995

Pengerusi: Dr. Che Roos Saad

Fakulti: Perikanan dan Sains Samudera

Empat makanan udang untuk *Penaus indicus* dirumus dengan bahan makanan asli yang mudah didapati (tepung kasar ikan, tepung kasar udang, tepung kasar kacang soya, tepung gandum, tepung jagung dan minyak jagung) dengan menggunakan kaedah pengaturcaraan linear. Semua makanan yang di sediakan adalah isokalorik (400 k cal/100g) dan mengandungi 5 hingga 11.5% lemak. Paras dieteri proteinnya ialah 30, 35, 40 dan 45% dengan profil asid amino sama seperti yang terdapat pada udang. Kos pengeluaran pemakanan tersebut adalah masing-masing 1140 Rial, 1240 Rial, 1340 Rial dan 1440 Rial per kilogram.

Lapan belas tangki konkrit dalam bangunan (3.45 m² tiap satu) yang dipenuhi air laut dari (42ppt) dengan kadar pengaliran air 2 l/saat ditempatkan bersama 138 anak udang *P. indicus* (0.014g berat min) dengan kadar perlepasan 40 udang per meter persegi. Lapan belas ruang (9.5 m² tiap satu) dalam kolam yang dipisah dengan
Jaring juga disediakan untuk menempatkan udang yang sama saiz dan kadar perlepasan seperti tangki di atas

Semasa 115 hari tempoh pembesaran, udang diberi makanan yang disediakan dan dua makanan komersil sebagai makanan kawalan untuk pertumbuhan, penggunaan makanan dan protein serta pembentukan karkas. Kadar Pertumbuhan Spesifik (SGR) adalah tinggi bagi semua makanan dengan julat antara 3.02 hingga 3.18 kecuali makanan komersil (Chenah) yang bernilai 0.81. Tiada perbezaan nyata \( P > 0.05 \) di kalangan makanan untuk pertumbuhan, kadar panjang maksimum, endapan lemak dan protein dalam tangki serta kolam.

Perbezaan yang nyata \( P < 0.05 \) dapat dilihat pada udang yang diberi makanan mengandungi 40% protein berbanding udang yang diberi makanan yang lain dalam memperolehi untung bersih, hasil, kadar kemandirian dan pertambahan berat badan. Keputusan juga menunjukkan bahawa udang \( P. indicus \) boleh diteran secara besar-besaran daripada ferai sehingga besar dalam air laut yang tinggi kemasinannya serta lebih ekonomik dengan makanan yang mengandungi protein optimum 40% jika dibandingkan dengan makanan-makanan yang lain.
CHAPTER I
INTRODUCTION

Background of the Study

Marine prawn is one of the most important high-value products in world trade. It is an important potential export item as well as foreign exchange earner in most of the Asian countries.

Prawn farming has seen rapid growth during the last decade. The reason for this is essentially increasing demand for prawn worldwide, both in the developed and developing countries (Rosenberry, 1994), diminishing supplies and increasing costs of marine landings of fish and prawns. However, from 1984 to 1993, world prawn landings stabilized at around 1.7 million metric tones (live weight) and it is thought to be close to the maximum sustainable yield (FAO, 1990; Rosenberry, 1994).

The Indian white shrimp *Penaeus (Fenneropenaeus) indicus* (H. Milne Edwards, 1837) culture has been found to be economical and profitable in Indonesia, Vietnam, Thailand, India and Philippines (Motoh; Buri, 1985). The total production of cultured *P. indicus* was estimated to be 43980 mt live weight constituting more than 6% of world cultured shrimp production of 733000 mt in 1994 (Csavas, 1994).
The distribution of the Indian white prawns *P. indicus*, is extensive, ranging from the Indo-west Pacific, east and the southeast of Africa to south of China, New Guinea and north of Australia. In nature, *P. indicus* is found at depths of 2 to 90 m with sand or mud bottom. The maximum total length is 184 mm for the male and 228 mm for the female with a maximum carapace length of 56 mm (Holthuis, 1980).

*P. indicus* is also an important item in the fisheries of Madagascar, Mozambique, Tanzania, Kenya and Somalia. In Kenya, it constitutes 75 to 90% of the catch (Brusher, 1976). Although the species is of minor importance in Yemen, the Persian Gulf and Pakistan (Tirmizi, 1969), it is the most important species in India (Johnson, 1967), especially in its inshore fishery (Kurian and Sebastian, 1976).

*P. indicus* is the most important species in the rice-field shrimp farming system of the Kerala coast of southwest India, as well as in Bangladesh, Thailand, Indonesia and the Philippines.

**Statement of the Problem**

Increased demand for prawn will have to be met by from aquaculture which at present is estimated to contribute only about 10% of total world fish landings (INFOFISH, 1995).

*P. indicus* offers good potential for development as a cultured species in south of the Islamic Republic of Iran, because of the long coastline (2000 km) much of which is suitable for marine fish and shrimp culture. Three of the world's most commercially important shrimp species such as the banana shrimp, *Peneaus merguiensis*, the tiger prawn, *Peneaus semisulcatus*, and the Indian white shrimp, *P.
*indicus*, are indigenous to the seas fringing the Iranian coastline (Persian Gulf and Oman sea). There is also a large expanse of flat, barren and saline land stretching along the southern coast of Iran which is unsuitable for agricultural purposes. This part of Iran could be utilised for shrimp culture.

In Iran the culture of *P. indicus* was started as a pilot project in the Kolahi station which is about 150 km east of Bandar Abass. Here, yields of up to 22500 kg/ha were obtained. This indicates that there is a good potential for the culture of *P. indicus* in Iran (Shilat Report, 1994).

About 1000 ha of coastal land in Iran is being developed for shrimp culture. The use of a nutritionally balanced diet will certainly improve shrimp production and increase profits. Feed is a major item in prawn farming constituting 55 to 65% of the total variable cost of production (Singh and Kamarudin, 1994, Hardman et al., 1991). Therefore, the economic efficiency of a farm is sensitive to both the cost and nutritional quality of the feed. Thus, feed quality and cost are directly related with an improvement in feed quality inevitably affecting feed cost. Therefore, feed quality and costs are critical factors in determining the profitability of shrimp production (Akiyama and Dominily, 1989). In the absence of a full-fledged feed mill industry in Iran, much of the shrimp feeds are imported. Thus, the cost of production of shrimp feed is very high as the market is monopolized by foreign producers. Therefore, the Iranian Fisheries Company (Shilat 1994) is working towards incorporating locally available feed ingredients to formulate least-cost diets which will reduce the production cost while still maintaining the competitiveness of the local feed mill industry. As a priority, a baseline nutritional study is to be undertaken with a view to
formulating a nutritionally balanced least-cost diet. Very few papers have been published on the use of local raw ingredients for shrimp feed in Iran and there is very little documented evidence on the nutrition of *P. indicus*. According to Akiyama et al. (1992), in general approximately 40 essential nutrients are required by the shrimp.

Protein and lipid are the major organic materials in animal tissues constituting 65-75% of total biomass on a dry weight basis. Protein is continuously being consumed by shrimp for growth and normal metabolism while lipids are highly digestible sources of energy. Protein is a component of tissue, while lipids are carriers of fat-soluble vitamins (Akiyama and Dominily, 1989). The recommended protein and lipid levels in commercial shrimp feeds are shown in Table 1. The locally available ingredients in Iran is shown in Table 2.

Table 1

<table>
<thead>
<tr>
<th>Size of shrimp (gm)</th>
<th>Protein level (%)</th>
<th>Lipid level (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 - 3.0</td>
<td>40</td>
<td>7.0</td>
</tr>
<tr>
<td>3.0 - 15.0</td>
<td>38</td>
<td>6.5</td>
</tr>
<tr>
<td>15.0 - 40.0</td>
<td>36</td>
<td>6.0</td>
</tr>
</tbody>
</table>

Source: Akiyama and Dominily (1989).
Table 2

The Locally Available Raw Feed Ingredients in Iran

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Cost (Rials/kg)</th>
<th>Protein %</th>
<th>Lipid %</th>
<th>Energy (kal/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish meal</td>
<td>850 000</td>
<td>60 000</td>
<td>6 000</td>
<td>4 020</td>
</tr>
<tr>
<td>Shrimp head meal</td>
<td>600 000</td>
<td>42 670</td>
<td>1 400</td>
<td>3 210</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>640 000</td>
<td>46 800</td>
<td>1 670</td>
<td>4 630</td>
</tr>
<tr>
<td>Wheat flour</td>
<td>300 000</td>
<td>12 570</td>
<td>1 360</td>
<td>4 320</td>
</tr>
<tr>
<td>Maize meal</td>
<td>600 000</td>
<td>9 800</td>
<td>3 500</td>
<td>3 569</td>
</tr>
<tr>
<td>Barley meal</td>
<td>300 000</td>
<td>11 900</td>
<td>n a</td>
<td>3 060</td>
</tr>
<tr>
<td>Industrial date</td>
<td>400 000</td>
<td>n a</td>
<td>n a</td>
<td>n a</td>
</tr>
<tr>
<td>Cotton-seed meal</td>
<td>300 000</td>
<td>42 000</td>
<td>2 000</td>
<td>2 550</td>
</tr>
<tr>
<td>Corn oil</td>
<td>2500 000</td>
<td>0 000</td>
<td>100 000</td>
<td>9 -9.65</td>
</tr>
<tr>
<td>Sunflower oil</td>
<td>2500 000</td>
<td>0 000</td>
<td>100 000</td>
<td>9 -9.8</td>
</tr>
</tbody>
</table>

Note 2700 Iranian Rials = US $1
n a = not available

Significance of the Study

The significance of the study is as follows

1. The increasing need to establish the dietary protein requirements of *P. indicus* because there is very little published information on the dietary needs of this species

2. The growing need to expand the aquaculture base (extensive, semi-intensive, or intensive) of *P. indicus* in Iran in the context of increasing fishing pressure in and around the Oman Sea and the Persian Gulf

3. The development of farm-made or commercial aquafeeds using mostly locally available agricultural and wastes products of agro-processing industries
4 The utilisation of locally available feed stuff to reduce production cost thus encourages *P.indicus* culture by professional and subsistence fishermen or the commercial enterprises

5 The abundance of *P.indicus* fry in the wild and hatchery system requires that baseline nutritional studies to establish *P.indicus* as a cultured species

6 The conducive physico-chemical parameters of the coastal waters seem to provide a suitable aquatic environment for the culture of *P.indicus*

7 The increasing demand for *P.indicus* both within IR Iran and the neighboring gulf states because of its relatively low price

8 Extensive or intensive culture of *P.indicus* offers good potential for the economic development of extensive wastelands or wetland along the coasts of IR Iran

9 *P.indicus* is one of the dominant species of the marine landings in and around the coastal waters of Iran

10 Fast growth and tolerance to a wide range of salinity levels and temperature gives *P.indicus* a relative advantage over other penaeid species and makes it a natural choice for culture (Udayakumara and Ponniah, 1988, Shilat Report, 1994)
Objectives

The objectives of this study are as follows:

(i) To formulate a suitable diet for *Penaeus indicus* using locally available raw feed ingredients.

(ii) To determine experimentally, the best growth response of *Penaeus indicus* fed on optimum least-cost feed using linear programming techniques (LINDO).
CHAPTER II

LITERATURE REVIEW

Though nutritional principles are similar for all animals, the quantity of required nutrients vary with species. There are approximately 40 essential dietary nutrients required by fish and terrestrial animals (Akiyama et al, 1992, Lovell, 1989, Stickney, 1979). These essential nutrients are assumed to be similar for shrimp and would include amino acids, fatty acids, energy, vitamins and minerals.

Protein Requirement for Fish

Sakaras et al (1987) found the optimal dietary protein levels for grow out of seabass to be about 45 to 50% with the dietary protein demand being higher during the larval stages. However, they did not study the energy content for the fish. Khan et al (1992) studied the optimal dietary protein requirement of Mystus nemurus cultured in tanks under semi-controlled environmental conditions in a recycling water system. The experimental fish were fed with six variable diets containing 27, 32, 37, 42, 47, and 50% protein. The fish were found to grow moderately when fed on a 42% protein diet which is the optimum feed. The principal protein sources were fish and soybean meals.
Yon and Fuji (1975) tested diets containing 30, 40, 50, 60, and 70% protein on red sea bream and found that a diet of 50% protein resulted in the highest growth rate.

**Protein and Energy Requirement for Penaeid Shrimps**

Akiyama (1988) reported that *P. monodon* fed with diets containing up to 40% soybean meal achieved good survival rates and best growth. He carried out the experiment using five shrimp diets which were extruded at low temperature and which had similar protein with different soybean meal contents (20, 30, 40, and 50% of soybean meal).

Pascal and Tabbu (1980) observed that juvenile *P. monodon* gave the best yield when fed with a diet containing 35% defatted soybean meal and 16% Peruvian fish meal.

Xinzhang and Lie (1988) who worked on optimum nutritional contents in the compound diet of *Penaeus orientalis* with body-weights ranging from 2.87-3.44 g found that 4.0% crude fat, 44% protein, 26% carbohydrate, 4.5% crude fibre and 4.5% calcium and phosphorus together with a 1:2 Ca/P ratio was the best combination. Crude fat content clearly has a restrictive effect on the transformation of protein while carbohydrate and crude fibre content have a limited effect. Under experimental conditions, the daily requirements of the nutritional composition of diet per kg *P. orientalis* are found to be as follows: protein 25.96 g, carbohydrate 15.34 g, crude fibre 2.66g, and crude fat 2.36 g. The daily feeding ratio was 5.9% of the body weight of *P. orientalis* (Xinzhang and Lie, 1988).