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Effects of Dietary Lipid and Energy to Protein Ratio on Growth and Feed Utilization of Juvenile Mutton Snapper *Lutjanus analis* Fed Isonitrogenous Diets at Two Temperatures

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Abstract

Growth and feed utilization of juvenile, hatchery-reared mutton snapper *Lutjanus analis* (mean weight = 12.2 g) were compared for 40 d in laboratory aquaria on four isonitrogenous diets (45% crude protein) of varying lipid content (6, 9, 12 and 15%) with energy:protein ratios (E:P; kJ/g protein) of 33.9, 36.3, 38.8, and 41.2, respectively. Growth on these diets was compared under temperatures of 25 and 30 C. Final weights (Wt_f) and specific growth rates (SGR) were higher ($P < 0.05$) at lower dietary E:P ratios of 33.9 and 36.3 (Wt_f = 20.3–22.0 g; SGR = 1.25–1.35%/d) than at E:P ratios of 38.8 and 41.2 (Wt_f = 17.2–17.7 g; SGR = 0.84–0.85%/d). Growth at 30 C (Wt_f = 21.5 g, SGR = 1.35%/d) was higher ($P < 0.05$) than at 25 C (Wt_f = 17.3 g; SGR = 0.82%/d). Feed consumption (FC) was higher ($P < 0.05$) at a dietary E:P ratio of 33.9 (1.57%/d) than at 36.3 (1.27%/d) or 38.8–41.2 (0.89–0.98%/d). Growth was highly correlated ($P < 0.01$) to E:P ratio and to feed consumption. Feed conversion ratio (FCR = 2.17–3.98), protein efficiency ratio (PER = 0.58–1.03) and apparent net protein retention (ANPR = 15.8–20.0%) were not significantly ($P > 0.05$) affected by dietary E:P ratio. Apparent net energy retention (ANER) was higher ($P < 0.05$) at E:P ratios of 33.9 and 36.3 (9.50–9.98%) than at E:P ratios of 38.8 and 41.2 (7.15–7.10%). Feed utilization parameters were significantly ($P < 0.05$) better at 30 C (FC = 1.36%/d; FCR = 2.6; PER = 0.88; ANER = 10.2%) than at 25 C (FC = 1.03%/d; FCR = 3.38; PER = 0.69; ANER = 6.72%), with the exception of ANPR (17.0–17.8%). Maximum growth and energy retention in juvenile mutton snapper using a diet containing 45% crude protein was obtained at dietary lipid levels of 6–9% and E:P ratios of 33.9–36.3 kJ/g protein. Studies which determine optimum protein levels and the effects of reducing E:P ratios below 33.9 kJ/g are needed to improve feed conversion and growth.

The mutton snapper *Lutjanus analis* is a medium size (< 12 kg) snapper that forms an important component of shallow water reef fisheries in the tropical and subtropical western Atlantic (Bortone and Williams 1986; Grimes 1987). Over-fishing of spawning aggregations has led to steep declines in landings in recent years and the total collapse of stocks in some regions (Brownell and Rainey 1971; Gulf of Mexico Fishery Management Council 1992). Diminishing natural populations and high market value and demand has stimulated interest in the artificial propagation of the mutton snapper for commercial cultivation or stock enhancement (Soletchnik et al. 1989; Watanabe et al. 1998, 2000; Benetti et al. 2000; Feeley et al. 2000).

Dietary lipids are a major source of energy among carnivorous fish species. While deficiencies in dietary lipid result in the catabolism of proteins as an energy source, excessive lipids can suppress appetite and

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reduce growth (Phillips 1972; Halver 1976; NRC 1983). The ratio of energy to protein (E:P ratio) producing highest growth in marine fish is species specific (Shimeno et al. 1980; El-Dakour and George 1981; Williams and Robinson 1988; Parazo 1990; Ellis and Reigh 1991; Ellis et al. 1996; Tibaldi et al. 1996) and may be influenced by temperature (Hidalgo and Alliot 1988; Woiwode and Adelman 1991).

Little or no information is available on the nutritional requirements of lutjanid snappers. Recently, successful spawning and rearing of mutton snapper larvae through metamorphic stages (Watanabe et al. 1998) has made available hatchery-reared juveniles for experimental studies. The objectives of this study were to determine the effects of dietary lipid and E:P ratio on growth and feed utilization in juvenile, hatchery-reared mutton snappers fed isonitrogenous diets (45% crude protein) reared at two temperatures (25 and 30 C).

Materials and Methods

This study was conducted at the Caribbean Marine Research Center (CMRC) on Lee Stocking Island, Exuma Cays, Bahamas, from September through October 1995. Approximately 200 juvenile mutton snapper of the same cohort (92 d post-hatching), originating from a hormone-induced voluntary spawning of captive broodstock (Watanabe et al. 1998) were used for the study. Fish were reared on a prepared diet and under an average temperature of 28.5 C.

Experimental units consisted of 145-L indoor glass aquaria (1.2 m long × 0.3 m wide × 0.5 m deep, l × w × d) covered on the tops, backs and on both sides by white polystyrene sheeting. Aquaria were supplied with flow-through seawater (36–38 g/L) at a rate of 0.1 L/min (one water exchange/d) and diffused aeration. Light was supplied by overhead fluorescent sources controlled by a timer to provide a 12 L:12 D photoperiod. Tank temperatures were maintained at prescribed levels using immersion heaters (300 W) to heat water against an ambient room temperature (21 C), maintained by an air-conditioner.

Growth, feed utilization, and body composition of juveniles were compared for 40 d on four semi-practical, isonitrogenous (45% crude protein; CP) pelleted diets (Zeigler Brothers Inc., Gardeners, Pennsylvania, USA) with varying lipid level and E:P ratio (Table 1) at two temperatures (25 and 30 C) in a 4 × 2 factorial design. Protein level (45%) was selected as a conservative level within the range (40–61%) used successfully for raising marine finfish (Tucker 1992). Dietary ingredients were identical except for lipid, which was varied at levels of 6, 9, 12, and 15%. Increases in dietary lipid were achieved by increasing the level of menhaden oil, while reducing the level of a non-nutritive cellulose filler (Solka Floc-40, Fiber Sales and Development Corporation, Green Brook, New Jersey, USA) to provide gross energy to crude protein (E:P; kJ/g protein) ratios of 33.9, 36.3, 38.8, and 41.2, respectively (Table 1). Energy:protein ratios were determined using physiological fuel values for all animals (Phillips 1972) and did not include the energy contained in the indigestible, Solka Floc-40. The protein component of the diets consisted of 83.5% animal protein from herring meal as a primary source.

Twenty-four aquaria were each stocked with eight fish, with three replicate aquaria per treatment. Fish were stocked at an ambient temperature of 28 C and acclimated to the treatment temperatures at a rate of 1 C/d prior to the start of the study. To start the experiment (day 0), fish were anaesthetized (75 mg/L tricaine methane sulfonate), weighed and measured. Initial weights, standard lengths and coefficient of variation of initial weights and standard lengths averaged 12.2 ± 0.16 g ($\bar{x}$ ± SEM), 7.01 ± 0.02 cm, 17.6% ± 1.19 and 6.65% ± 0.47, respectively, and did not differ significantly ($P > 0.05$) among treatment groups.

From day 0, fish were hand fed twice daily (0815 and 1515) to satiation, a level that

TABLE 1. *Feed ingredients and proximate composition of four isonitrogenous (45% CP), semi-practical diets fed to juvenile mutton snappers for 40 d at 25 and 30 C.*

Ingredient (%)	Diet (% lipid) 6	9	12	15
Herring meal (70% CP: 8% CL)	40.0	40.0	40.0	40.0
Wheat flour	20.0	20.0	20.0	20.0
Solka Floc-40[a]	9.00	6.00	3.00	0
Soybean meal (48.5% CP)	5.00	5.00	5.00	5.00
Shrimp meal	5.00	5.00	5.00	5.00
Squid liver powder	5.00	5.00	5.00	5.00
Blood meal (85% CP)	3.50	3.50	3.50	3.50
Menhaden oil	0	3.00	6.00	9.00
Abernathy vitamin #2[b]	3.00	3.00	3.00	3.00
Feather meal (80% CP: 8% CL)	3.00	3.00	3.00	3.00
Gluten (60% DP)	2.50	2.50	2.50	2.50
Brewer's yeast	1.00	1.00	1.00	1.00
Lecithin	1.00	1.00	1.00	1.00
Monosodium phosphate	1.00	1.00	1.00	1.00
Choline	0.40	0.40	0.40	0.40
Vitamin C[c] (15%)	0.40	0.40	0.40	0.40
USFW #3 minerals[d]	0.20	0.20	0.20	0.20
Nutritional composition (%)	**Diet (% lipid) 6**	**9**	**12**	**15**
Moisture	8.77	8.65	8.53	8.41
Crude protein (CP)[e]	44.9	44.9	44.9	44.9
Crude lipid (CL)[e]	6.13	9.13	12.1	15.1
Crude ash (CA)[e]	8.00	7.99	7.98	7.97
Crude fiber (CF)[e]	10.3	7.53	4.72	1.91
Nitrogen free extract (NFE)[e,f]	30.6	30.5	30.3	30.1
Gross energy (kJ/g diet)[g]	15.2	16.3	17.4	18.5
Energy : protein ratio (kJ/g CP)	33.9	36.3	38.8	41.2

[a] Flavorless, non-nutritive, powdered cellulose (Fiber Sales and Development Corporation, Green Brook, New Jersey, USA).
[b] Vitamin premix (BASF Corporation, Mount Olive, New Jersey, USA).
[c] Stay C® (25% active, Hoffmann LaRoche, Inc., Nutley, New Jersey, USA).
[d] Trace mineral premix (Nutrition Service Association, Ephrata, Pennsylvania, USA).
[e] Percent dry matter.
[f] NFE calculated by subtraction [100 − (CP + CL + CA + CF)].
[g] Calculated using physiological fuel values (Phillips 1972).

ranged from approximately 0.9–1.8% body weight/d. The daily ration was based on a specified percentage of the tank biomass determined at the last sampling. At each feeding, a level of feed was provided so that a slight excess remained after 10 min, which was completely consumed within 20 min. A satiation feeding level with minimal wastage was maintained by adjusting the feeding rate daily by 0–0.5% of tank biomass according to this observation.

To monitor growth, fish were individually weighed and measured at the end of the experiment, and fish in each replicate aquaria were mass weighed every 2 wk. Feces were siphoned daily after the morning feeding. One replicate tank in the 15% lipid (30 C) treatment was accidentally lost due to handling stress during sampling on d 13.

Temperature, measured daily, averaged 25.8 ± 0.02 and 30.0 ± 0.02 C in the 25 and 30 C treatments, respectively. Dissolved oxygen and pH were measured daily in one tank from each treatment. Total ammonia-nitrogen was measured in each tank every 10 d.

A sample of 10 fish collected at the start of the experiment, and 12 fish from each treatment at the end of the study, were pooled and analyzed for proximate composition using standard AOAC methods (AOAC 1984).

Daily weight gain (g/d) was calculated from DWG = [final weight (g) − initial weight (g)]/time in days.

Relative growth rate (% increase in weight) was calculated from RGR = [(wet final weight (g) − wet initial weight (g))/ wet initial weight (g)] × 100.

Specific growth rate (% increase in body weight per day) was calculated from SGR = [(ln wet final weight (g) − ln wet initial weight (g))/time in days] × 100.

Feed consumption (% of body weight per day) was calculated from FC = (dry weight feed consumed (g))/(final weight (g) + initial weight (g))/2).

Feed conversion ratio was calculated from FCR = dry weight of feed (g)/wet weight gain (g).

Protein efficiency ratio was calculated from PER = wet weight gain (g)/dry weight protein fed (g).

Apparent net protein retention was calculated from ANPR = [(final wet weight (g) × final body protein (%)) − (initial wet weight (g) × initial body protein (%))/dry weight protein fed (g)] × 100.

Apparent net energy retention (ANER) was calculated from ANER = [((final wet weight × final kJ energy/body weight (g)) − (initial wet weight × initial kJ energy/ body weight (g)))/kJ energy fed on dry weight basis] × 100.

Treatment means were compared by two-way analysis of variance (Sokal and Rohlf 1969). Following a significant ANOVA, multiple comparisons among means were performed using the Ryan-Einot-Gabriel-Welsch Multiple Range Test (Day and Quinn 1989). Feed consumption and dietary E:P ratio were correlated to growth and feed utilization parameters using linear regression.

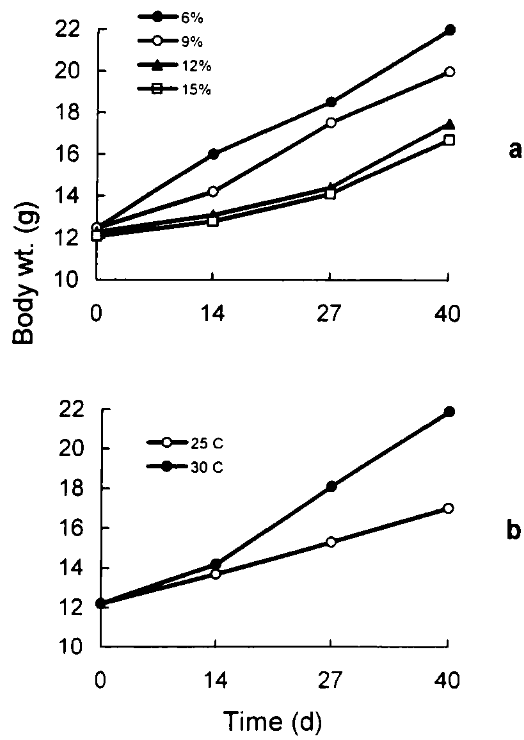

FIGURE 1. *Growth of juvenile mutton snapper fed four isonitrogenous (45% CP), semi-practical diets with different crude lipid levels and E:P ratios at 25 and 30 C. Fig. 1a shows growth at different lipid levels integrated for both temperatures, while Fig. 1b shows growth at both temperatures, integrated across all dietary lipid levels. Plotted points represent* x̄ *(*N *= 5–6 in Fig. 1a;* N *= 11–12 in Fig. 1b).*

Results

A clear departure in growth rates among the dietary lipid and temperature treatments were observed by day 14. Growth increased with decreasing dietary lipid (Fig. 1a) and was higher at 30 C than at 25 C (Fig. 1b). Significant effects of both dietary lipid (and E:P ratio) ($P < 0.01$) and temperature ($P < 0.05$) on growth rates were observed, with no interaction between these effects. Final weight (Wt_f) (Fig. 2), final length (Lt_f), specific growth rate (SGR) (Fig. 3), daily weight gain (DWG) and relative growth rates (RGR) were significantly ($P <$

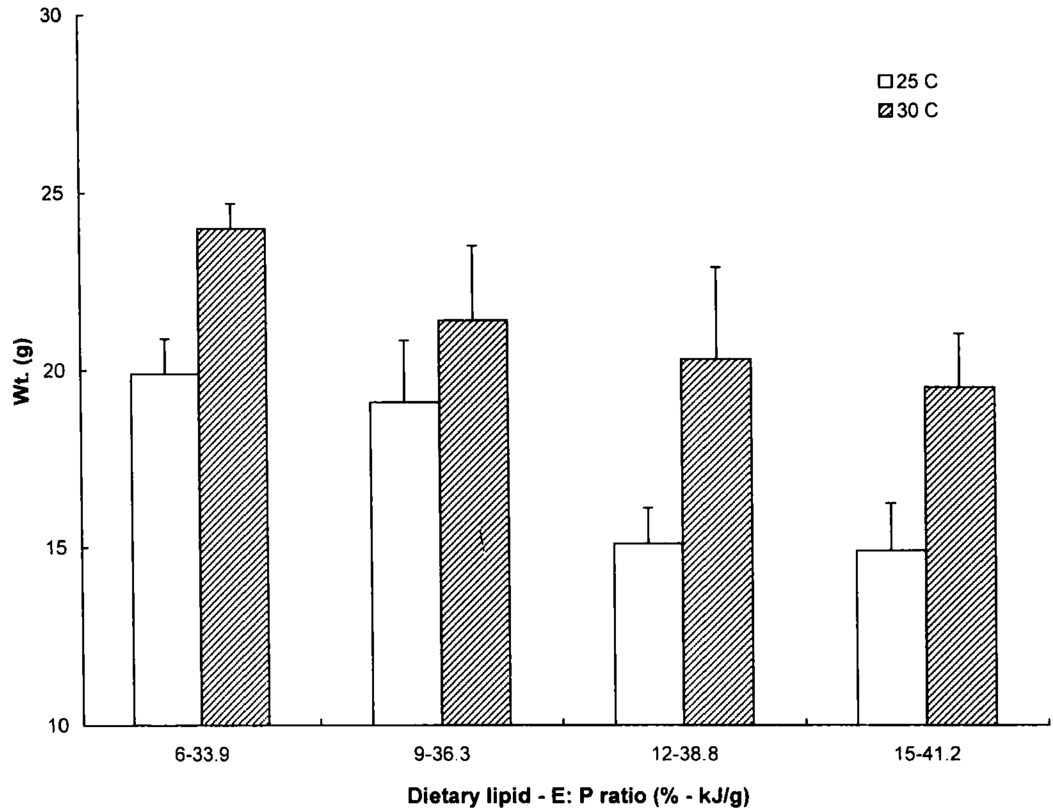

FIGURE 2. *Final weights of juvenile mutton snapper fed four isonitrogenous (45% CP), semi-practical diets with different crude lipid levels and E:P ratios at 25 and 30 C. Data represent* $\bar{x} \pm$ *SEM* (N = *3), except for treatment 15%–41.2 kJ/g (30 C) where* N = *2.*

0.05) higher at dietary lipid levels of 6 and 9% and E:P ratios of 33.9 and 36.3 kJ/g protein (Wt_f = 20.3–22.0 g, Lt_f = 8.59–8.71 cm, SGR = 1.25–1.35%/d, DWG = 0.20–0.23 g/d and RGR = 65.6–74.7%) than at lipid levels of 12 and 15% and E:P ratios of 38.8 and 41.2 kJ/g protein (Wt_f = 17.2–17.7 g, Lt_f = 8.06–8.19 cm, SGR = 0.84–0.85%/d, DWG = 0.13 g and RGR = 42.3–44.7%) (Table 2). Growth in weight at 30 C (Wt_f = 21.5 g, SGR = 1.35%/d, DWG = 0.23 g, RGR = 74.4%) was significantly ($P < 0.05$) higher than at 25 C (Wt_f = 17.3 g, SGR = 0.82%/d, DWG = 0.12 g, RGR = 40.1%) (Table 2). Growth at each temperature was inversely correlated ($P < 0.01$) to E:P ratio.

Coefficient of variation of final weights and lengths ranged from 12.6–30.0% and 4.17–9.14% (Table 2), respectively, with no significant treatment effects observed on these parameters. Survival to day 40 remained high in all treatments (93.8–100%) and was not significantly ($P > 0.05$) affected by dietary lipid level or by temperature (Table 3).

Significant ($P < 0.001$) effects of dietary lipid and temperature on feed consumption were observed, and there was a significant ($P < 0.05$) interaction between these effects (Fig. 4). Feed consumption decreased with increasing dietary lipid from 1.57%/d in the 6% diet to 0.95%/d in the 15% diet and was higher at 30 C (1.36%/d) than at 25 C (1.03%/d). However, these differences were pronounced in the 6% diet (Fig. 4). Feed

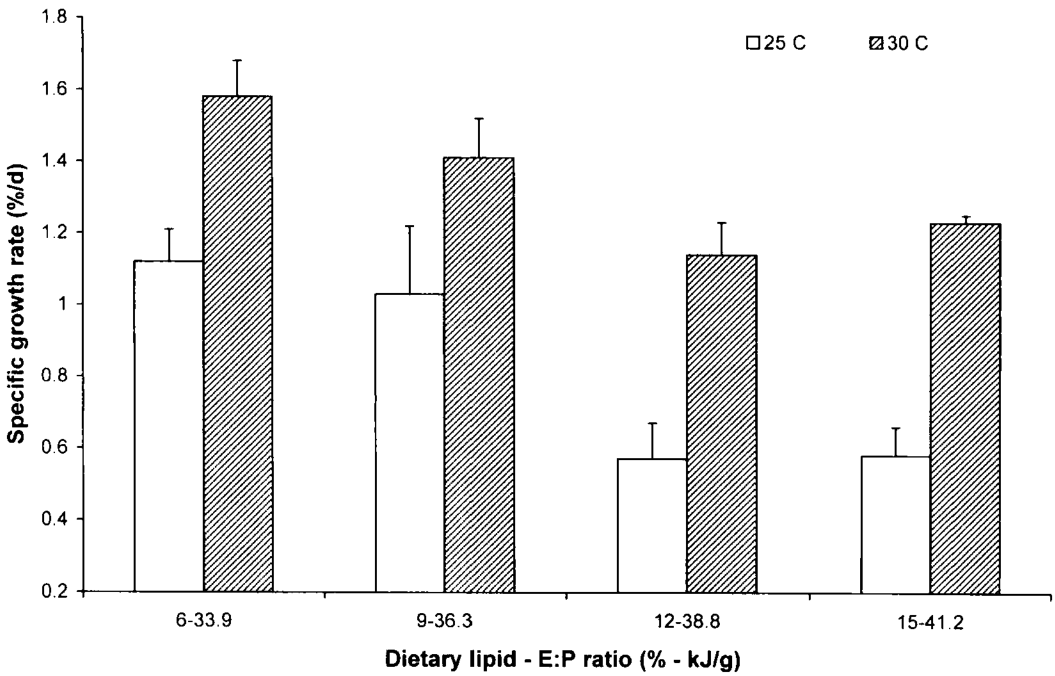

FIGURE 3. *Specific growth rates of juvenile mutton snapper fed four isonitrogenous (45% CP), semi-practical diets with different crude lipid levels and E:P ratios at 25 and 30 C. Data represent* x̄ ± *SEM* (N = *3), except for treatment 15%–41.2 kJ/g (30 C) where* N = *2.*

consumption was inversely correlated with E:P ratio ($P < 0.0001$).

Feed conversion ratio (range = 2.17–3.98) and PER (range = 0.58–1.03) were not significantly ($P > 0.05$) affected by dietary lipid and E:P ratio. FCR was lower and PER higher ($P < 0.05$) at 30 C (FCR = 2.60; PER = 0.88) than at 25 C (FCR = 3.38; PER = 0.69) (Table 3).

Apparent net protein retention (range = 15.8–20.0%) was not significantly influenced by dietary lipid or by temperature (Table 3). Apparent net energy retention was significantly affected by dietary lipid ($P < 0.05$) and by temperature ($P < 0.01$). ANER was higher in the 6 and 9% lipid diets (avg. = 9.74%) than in the 12 and 15% diets ($\bar{x}$ = 7.12%) (Table 3) and was higher for fish held at 30 C (avg. = 10.2%) than for fish held at 25 C ($\bar{x}$ = 6.72%) (Table 3).

Although data on proximate analyses of fish from each treatment at the end of the study could not be analyzed statistically (due to pooling of fish within each treatment), component values were similar among all treatments (Table 4).

Dissolved oxygen (DO) averaged 4.95 ± 0.03 mg/L and was significantly ($P < 0.05$) higher at 25 C (5.34 ± 0.03 mg/L) than at 30 C (4.56 ± 0.04 mg/L). Mean total ammonia-nitrogen (0.21 ± 0.02 mg/L) and pH (8.08 ± 0.009) did not differ significantly ($P > 0.05$) among treatments.

Discussion

The dietary E:P ratios of 33.9–36.3 kJ/g protein producing highest growth of juvenile mutton snapper in this study fall in the mid-range of optimum values reported for other marine finfish species which range from 23.4 to 45.8 kJ/g protein (Shimeno et al. 1980; El-Dakour and George 1981; Lim 1985; Parazo 1990; Tucker 1992; Ellis et al. 1996; Tibaldi et al. 1996). As in most marine finfish, an inverse relationship be-

TABLE 2. *Final weights and lengths, CV of final weights and lengths, daily weight gain (DWG) and relative growth rate (RGR; ± SE) of juvenile mutton snapper fed four isonitrogenous (45% CP), semi-practical diets with different crude lipid levels and E:P ratios at 25 and 30 C. Values represent x̄ ± SEM (N = 3), except for the 15%–41.2 kJ/g (30 C) treatment where N = 2.*

	Dietary lipid–E:P ratio (%–kJ/g)				
	6–33.9		9–36.3		12–38.8
Temperature (C)	25	30	25	30	25
Final weight (g)	19.9 ± 0.98	24.0 ± 0.71	19.1 ± 1.74	21.4 ± 2.11	15.1 ± 1.01
Final length (cm)	8.49 ± 0.18	8.93 ± 0.09	8.43 ± 0.18	8.74 ± 0.32	7.82 ± 0.19
CV final weight (%)	21.6 ± 1.98	12.6 ± 1.69	19.8 ± 2.08	20.8 ± 5.82	30.0 ± 4.14
CV final length (%)	7.55 ± 0.73	4.17 ± 0.67	6.38 ± 0.65	7.38 ± 1.73	9.14 ± 1.56
DWG (g)	0.18 ± 0.02	0.29 ± 0.01	0.16 ± 0.04	0.23 ± 0.06	0.08 ± 0.02
RGR (%)	56.6 ± 6.09	92.7 ± 4.06	52.0 ± 11.3	78.9 ± 13.5	25.5 ± 5.55

tween growth and dietary lipid was related to a suppression of appetite at high dietary lipid and energy levels (Halver 1976; Marias and Kissil 1979; Williams and Robinson 1988; Ellis et al. 1996). This stresses the importance of a proper E:P ratio as well as an adequate dietary protein level for optimal growth. Lower growth of fish held at 25 C than at 30 C was also due to decreased feed consumption, probably related to a lower metabolic rate (Brett 1979; Hidalgo et al. 1987; Woiwode and Adelman 1991; Ellis et al. 1997).

Feed and protein utilization were not affected by dietary lipid and E:P ratio, with the exception of ANER which was significantly lower in the high lipid (12 and 15%), high E:P ratio (38.8–41.2 kJ/g) diets. This suggests that, at these higher lipid levels, the fish had reached a metabolic limit for efficient lipid catabolism (Berger and Halver 1987), reducing energy retention.

Overall FCRs (range = 2.17–3.98) in this study, while within the range of values reported for other marine finfish species fed formulated diets (Parazo 1990; Tucker 1992; Ballestrazzi et al. 1994; Ellis et al. 1996; Tibaldi et al. 1996), were moderate to poor when compared to best values, which approach unity. This can be attributed to a number of possible causes. The inclusion of a non-nutritive filler (Solka-floc 40) in these semi-practical diets (Table 1) probably increased feed conversion ratio, particularly in the lower lipid diets. In addition, experimental diets in the present study contained protein from various animal and plant sources (Table 1). Since the digestibility of these protein sources for juvenile mutton snapper are unknown, it is

TABLE 3. *Survival, feed conversion ratio (FCR), protein efficiency ratio (PER), apparent net protein retention (ANPR) and apparent net energy retention (ANER) of juvenile mutton snapper fed four isonitrogenous (45% CP), semi-practical diets with different crude lipid levels and E:P ratios at 25 and 30 C. Values represent x̄ ± SEM (N = 3), except for the 15%–41.2 kJ/g (30 C) treatment where N = 2.*

	Dietary lipid–E:P ratio (%–kJ/g)				
	6–33.9		9–36.3		12–38.8
Temperature (C)	25	30	25	30	25
Survival (%)	95.8 ± 4.17	95.8 ± 4.17	95.8 ± 4.17	95.8 ± 4.17	100 ± 0.0
FCR	3.04 ± 0.16	2.86 ± 0.09	3.02 ± 0.47	2.66 ± 0.34	3.98 ± 0.56
PER	0.74 ± 0.04	0.78 ± 0.02	0.78 ± 0.12	0.87 ± 0.13	0.58 ± 0.09
ANPR (%)	17.1 ± 0.47	15.8 ± 0.35	16.6 ± 1.73	17.5 ± 1.76	16.6 ± 1.10
ANER (%)	8.49 ± 0.60	10.5 ± 0.32	9.46 ± 1.57	10.5 ± 1.68	4.81 ± 1.09

TABLE 2. *Extended.*

Dietary lipid–E:P ratio (%–kJ/g)		
12–38.8	15–41.2	
30	25	30
20.3 ± 2.59	14.9 ± 1.33	19.5 ± 1.51
8.55 ± 0.35	7.82 ± 0.29	8.29 ± 0.11
18.1 ± 1.42	18.3 ± 1.73	26.6 ± 2.00
5.49 ± 0.12	6.07 ± 0.73	8.36 ± 0.58
0.19 ± 0.05	0.08 ± 0.02	0.19 ± 0.01
59.1 ± 7.61	26.2 ± 3.48	63.1 ± 1.41

possible that these diets provided an imbalance of amino acids. Inclusion of soybean meal in the diets, which is not palatable to some species (Davis et al. 1995), could also have lowered FCR. In addition, these non-extruded diets contained 20% wheat flour, which was probably poorly digested, as carnivorous species have a limited ability to digest carbohydrates (Tacon 1990). Finally, since ANPR and PER did not vary with E:P ratios in this study, dietary energy levels were apparently adequate to spare protein in all diets, suggesting that dietary protein level (set at 45% in this study) was too low to support optimal growth. Amino acid imbalance and insufficient dietary protein both reduce protein assimilation and growth in fish (Halver 1976; Millikin 1983; NRC 1983; Parazo 1990).

While a combination of the factors discussed above probably limited feed conversion and growth in this study, inadequate dietary protein was probably a primary cause. In Nassau grouper *Epinephelus striatus*, a carnivorous marine species, FCR of hatchery-reared juveniles fed different commercially prepared diets increased from 0.94 on a 56% protein (7.8% lipid) diet to 5.55 on a 44% protein (5.9% lipid) diet (Ellis et al. 1996). In a commercial-scale study conducted concurrently to the present study, juvenile mutton snapper (of the same cohort) fed a commercially-prepared diet containing 55% protein and 10% lipid showed a feed conversion ratio of 1.2 (Watanabe et al. 1998). Recently, FCRs as low as 0.79–1.4 have been obtained with hatchery-reared juvenile mutton snapper fed commercially-prepared diets containing 50–53% protein and 13–14% crude fat in flow-through tanks and floating cages (D. Benetti, University of Miami, personal communication). The available information suggests that increasing dietary protein above 45% while maintaining a gross energy level of 15–16 kJ/g of diet would lower the E:P ratio and improve feed conversion and growth.

TABLE 3. *Extended.*

Dietary lipid–E:P ratio (%–kJ/g)		
12–38.8	15–41.2	
30	25	30
91.7 ± 8.33	100 ± 0.0	93.8 ± 6.25
2.58 ± 0.32	3.48 ± 0.27	2.17 ± 0.12
0.89 ± 0.13	0.65 ± 0.05	1.03 ± 0.06
18.7 ± 1.76	17.9 ± 0.74	20.0 ± 1.01
9.48 ± 1.37	4.10 ± 0.62	10.1 ± 0.56

In this study, feed utilization (FCR, PER and ANER) and growth were clearly lower in animals held at 25 C than in those held at 30 C. Lower feed conversion efficiency at lower temperature within a species ecological range has been observed in channel catfish *Ictalurus punctatus* (Murray et al. 1977) and sea bass *Dicentrarchus labrax* (Hidalgo et al. 1987; Hidalgo and Alliot 1988). In *D. labrax* this was attributed to decreased protein digestibility caused by lower trypsin activity in the gut and an increase in the energy required to synthesize protein.

To summarize, the results clearly demonstrate the effects of dietary lipid (and E:P ratio) and temperature on growth of juvenile mutton snapper. At temperatures of 25 and 30 C, maximum growth and energy retention in juvenile mutton snapper using a diet containing 45% crude protein was ob-

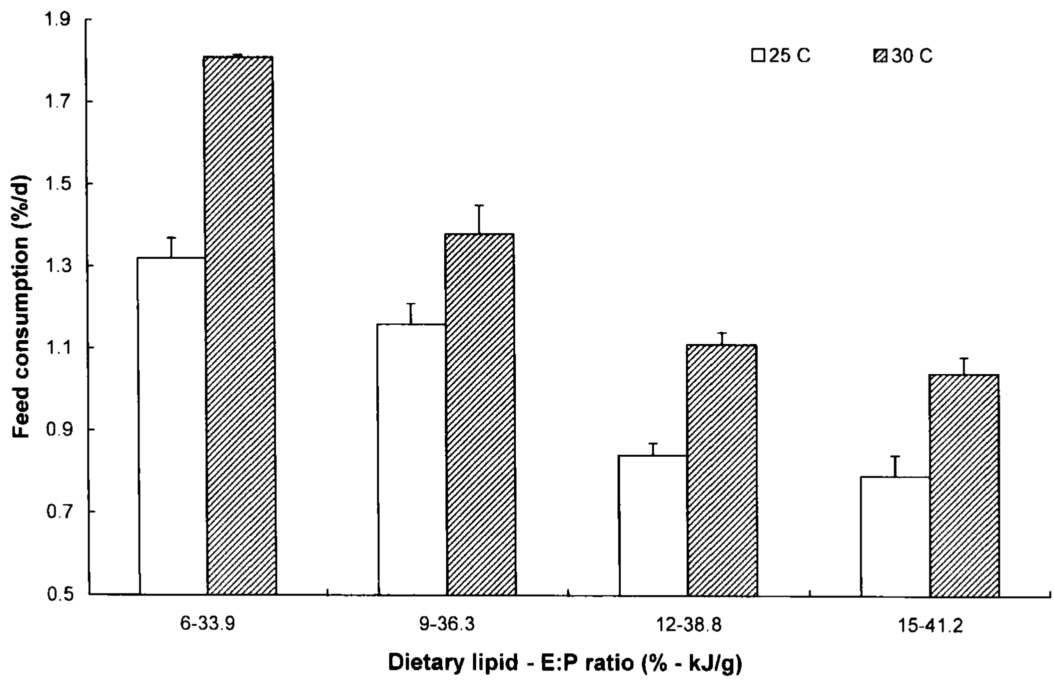

FIGURE 4. *Feed consumption in juvenile mutton snapper fed four isonitrogenous (45% CP), semi-practical diets with different crude lipid levels and E:P ratios at 25 and 30 C. Data represent x̄ ± SEM (N = 3), except for treatment 15%–41.2 kJ/g (30 C) where N = 2.*

tained at dietary lipid levels of 6–9% and E:P ratios of 33.6–36.3 kJ/g protein. Growth and feed utilization were better at 30 C than at 25 C. Studies that determine optimum protein levels and the effects of reducing E:P ratios below 33.9 kJ/g are needed to improve feed conversion and growth.

TABLE 4. *Initial and final composition (% dry matter) of juvenile mutton snapper fed four isonitrogenous (45% CP), semi-practical diets with different crude lipid levels and E:P ratios at 25 and 30 C. Values represent readings for pooled samples, where N = 10 individuals initially and N = 12 individuals per treatment for final composition.*

		Dietary lipid–E:P ratio (%–kJ/g)							
		6–33.9		9–36.3		12–38.8		15–41.2	
Temperature (C)		25	30	25	30	25	30	25	30
	Initial	Final							
Component									
Moisture (%)	78.6	74.3	74.7	75.1	75.1	75.0	75.6	74.9	75.8
Crude protein (CP; %)	64.4	66.7	66.9	65.7	66.0	66.8	67.2	66.2	65.9
Crude lipid (CL; %)	14.5	10.1	12.0	12.9	12.5	10.6	11.4	9.70	12.2
Crude ash (CA; %)	20.1	21.6	20.3	20.6	20.7	21.7	21.1	23.4	21.7
Crude fiber (CF; %)	0.41	0.52	0.78	0.54	0.23	0.25	0.19	0.40	0.25
NFE[a]	0.59	1.08	0.02	0.26	0.57	0.65	0.11	0.30	0.0
Gross energy (kJ/g)	16.2	15.0	15.8	15.9	15.8	15.2	15.6	14.8	15.6

[a] NFE = 100 − (CP + CL + CA + CF).

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