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Hormonal Relationships to Milk Yield, Energy Balance and Breeding Effic~~c~~ie~~c~~ency in Dairy Cattle

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Hormonal Relationships to Milk Yield, Energy Balance and Breeding Efficiency in Dairy Cattle

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A. ABSTRACT

During 5 years on BARD project I-106-79 276 Holstein Cows at The Volcani Center were individually fed two levels of nutrition, 110 and 160% of NRC standards prepartum, weighed, scored for body condition and energy balances calculated. Also, milk production, dates of estrus, breeding, conception and calving were recorded. There was no plan to collect blood samples, but this valuable resource material was added. Blood samples were taken at a uniform time each week and serum was frozen. Radioimmunoassays (RIA's) for bovine metabolic hormones were already validated at Cornell.

The objective of the current proposal was to utilize a portion of this resource by selecting two groups of 20 multiparous cows, each representing the extremes in milk yield and energy balance from the two nutrition groups and measuring their growth hormone (GH), insulin, 3,5',-triiodothyronine (T_3) and thyroxine (T_4). The period of measurement covered 4 weeks before to 15 weeks after calving, a critical period surrounding parturition, peak milk yield and rebreeding.

Graphs are presented illustrating the dynamic changes which take place in all measurements for each week for all three paired groups of cows. The least square means and standard errors for each week and each group, along with analyses of variance and statistical significance are included. Of particular interest is insight gained into cows with prolonged negative energy balances with associated low reproductive performance and consistently lower blood insulin concentrations.

B. OBJECTIVES

Blood samples collected at weekly intervals were available from two groups of 20 multiparous cows each, selected to differ in performance and energy balance. These samples were assayed for several important hormones affecting energy metabolism: insulin, growth hormone, 3,5,3′-triiodothyronine (T_3) and thyroxine (T_4).

Our hypothesis was that these hormones reflect an interplay which some cows shift and/or balance more effectively than others, thus enabling these cows to optimize performance. Specifically the following was planned:

1. Assay serum for growth hormone (GH), insulin, T_3 and T_4.
2. Relate the changes in blood serum concentrations of these hormones singly and in combination to milk production, body weight changes, energy balance and breeding efficiency. We have derived a formula to calculate energy balance from feed intake, body weight and milk production.
3. Predict approximate ranges in hormone profiles, which should be maintained through feeding and management, to have a most effective dairy cattle operation.

C. REPORT

Hormonal Relationships to Milk Yield, Energy Balance, and Breeding Efficiency in Dairy Cattle.

1. Introduction

Enormous strides have been made in the genetic improvement of dairy cattle, primarily through several generations of sire selection and use of their semen for artificial insemination (A.I.). There has been considerable progress in management. Yet full advantage of the genetic potential of these cattle, improved through selection, is not currently realized because we do not have enough information on proper feeding and the optimal time to breed these potentially high producing cows. Calving intervals are too long (Bratton, 1983) for optimal daily or annual milk production. Extended calving intervals are estimated to represent a yearly loss in the USA alone of $500,000,000., i.e. the difference if maximum efficiency of production was achieved.

Although infertility often is associated with pathological conditions of the thyroid gland (i.e. hypothyroidism), as well as the pituitary gland and pancreas (i.e. diabetes mellitus), relatively little is known about the relationship between metabolic hormones, milk yield and reproductive functions in healthy animals. It is likely that GH, insulin, T_3 and T_4 potentiate mechanisms responsible for development of ovarian follicles, development and maintenance of corpora lutea, and viability of the conceptus, primarily by mobilizing metabolic substrates for synthesis of steroids, amino acids, carbohydrates, and proteins. Several studies have been done in laboratory and ruminant animals to describe changes in these hormones during the reproductive cycle, particularly with the interest in administering GH. Milk production is increased by administration of GH (Peel et al., 1982, 1983; Eppard et al., 1985). Barnes et al (1985) found higher GH in the blood of daughters of dairy sires with the highest predicted difference in milk production.

The thyroid gland and endocrine pancreas are important for normal reproductive function in cattle (McCann et al., 1983). In this study two heifers did not exhibit estrous behavior and both had high T_3 and T_4.

Insulin concentrations in ruminant and nonruminant animals decrease at the time of parturition (Schwalm and Schultz, 1976) and then increase as lactation progresses (Koprowski and Tucker, 1973; Smith et al., 1976). McCann and Reimers (1982, 1983) found that obese heifers exhibited basal hyperinsulimia even though basal concentrations of glucose were the same. Reimers and McCann (1982) found that "Rompun," a sympathomimetic drug, which may cause marked hyperglycemia and hypoinsulinemia, decreased serum insulin and increased glucose closely associated with a transient decrease in concentration of progesterone.

Hormonal requirements for lactation in cattle have not been completely elucidated. It is known, however, that GH, thyrotropin-releasing hormone, thyroid stimulating hormone, T_3, T_4 and insulin affect galactopoiesis in dairy cattle. The administration of GH (Peel et al, 1982, 1983; Eppard et al., 1985) has a major effect on milk production. Swanson and Miller (1973) reported that T_3 and T_4 were necessary for maximal milk production. Hart et al. (1978, 1979) reported significant correlations between GH and T_4 ratios and T_4 alone and milk production. Both T_3 and insulin also have been reported to be correlated with milk yield (Walsh et al., 1980).

The objectives of the current study were listed previously. Primarily, the objectives were to determine if cows differing in production differed in any of the four hormones to be measured and to establish relationships regarding the ability of the animals to minimize a negative energy balance and maintain superior production.

2. Materials and Methods

Animals and Treatment. There were 40 multiparous Holstein cows selected from a larger group on the basis of differences in production and body weight loss. Thus the animals represented two groups of 20 cows each differing considerably in energy balance.

Two months before the first and subsequent calvings, cows on experiment were matched as closely as possible and assigned to receive either 100% or 160% of the energy recommended by NRC (1978), with daily intake held at the same level in both diets. Rations were calculated according to body weight and adjusted twice weekly. During the first 150 days of lactation, cows were fed ad libitum a diet of 35% hay and 65% concentrate. After 150 days, they were fed according to NRC recommendations.

Milk yield was recorded three times a day. Feed consumption was measured daily and cows were weighed weekly. Every two weeks, animals were scored for body condition and examined by a veterinarian for general reproductive health. Dates of behavioral estrus and insemination were recorded throughout the open period.

Blood. Peripheral blood was sampled weekly in heparinized, evacuated tubes from 4 weeks before calving through 15 weeks postpartum. The samples were always taken immediately after the morning milking the same day each week. Samples were centrifuged immediately and the plasma frozen and stored at -20^{o}C. Samples of blood plasma were packed in Dry Ice in Israel. They went through an approved holding and gamma radiation treatment in the U.S. before being released to Cornell. They were stored continuously frozen at -20^{o}C at Cornell until thawed and assayed. Previous studies by Reimers et al., (1983) have shown that T_3, T_4 and insulin were stable throughout a holding period of 8 days at 4^{o}C. Thus, once a sample is thawed all assays can be run while it is held at 4^{o}C without requiring repeated freezing and thawing. All assays included quality control samples randomly distributed throughout the assays.

Radioimmunoassays.

Concentrations of T_3, T_4, and insulin in plasma samples were determined by validated radioimmunoassays as described previously (Reimers et al., 1981, 1982, 1983). For the T_3 assay, 100 μl of sample or standard, 100 μl of $[^{125}I]3'-T_3$ solution (approximately 25,000 cpm), and 800 μl of an aqueous solution of 8-anilino-1-naphthalene sulfonic acid and sodium barbitol (to dissociate T_3 from binding proteins) were added to duplicate 8 x 50 mm polypropylene tubes coated with rabbit anti-T_3 serum. After incubation for 3 h at 37°C, the tubes were aspirated and rinsed twice with deionized water. Radioactivity remaining bound to the tubes was quantified in an automatic gamma counter and results analyzed with a computer program involving iterative least-squares weighted regression (Robard and Lewald, 1970; Robard, 1974).

In the T_4 assay (Reimers et al., 1981, 1983), all samples initially were diluted 1:5 with deionized water. Diluted samples (20 μl) or standards (20 μl), $[^{125}I]3'-T_4$ (100 μl), and buffer described above (880 μl) were added to duplicate polypropylene tubes coated with rabbit anti-T_4 serum. Tubes were incubated for 1 h at 37°C, aspirated, and rinsed as described above.

The insulin radioimmunoassay (Reimers et al., 1982, 1983) also used polypropylene tubes, coated with guinea pig anti-porcine insulin serum. One hundred microliters of sample of standard, 100 μl of $[^{125}I]$ iodoinsulin (porcine) and 800 μl of phosphate-buffered saline was incubated in the tubes for 18 h at room temperature (20-22°C). The tubes were aspirated and rinsed as above.

Bovine serum GH (200 μl in duplicate) was measured by double antibody radioimmunoassay. Purified (Miles Laboratories) 77-001, lot 12) bovine GH was used to prepare ^{125}I-labeled tracer. A 1:3500 dilution of a monkey antiserum to bovine GH AFP-55 or rabbit antiserum to bovine GH (NIH-GH-b18) were used as the primary antibody. Separation of antibody bound GH from unbound GH was accomplished by immunoprecipitation with goat anti-monkey or anti-rabbit gamma globulin serum. Radioactivity in precipitates was quantified in a gamma counter after a 3-ml wash with ice cold phosphate-buffered saline and centrifugation at 1000 x g.

Although two different antisera were used, the iodinated hormone and reference preparation were the same for all determinations. Standard tubes contained from 2.5 to 320 ng/ml of bovine GH (Miles Laboratories, 77-001, lot 12) were assayed with each batch of unknowns. This assay gave high recoveries, low intra- and inter-assay coefficients of variation and the assay did not crossreact with TSH, LH or prolactin.

Statistical Analysis and Presentation of the Data

Following editing of the data consisting of about 700 values each for bovine growth hormone (bGH), insulin (INS) T_3, T_4, body weight (WT), fat corrected milk (FCM), energy of the ration (TDNRAT), energy balance (EBAL) and cumulative energy balance (CUMBAL), the data were graphically displayed to obtain a better perspective of the nature of the results. All measurements taken daily and energy balance calculated daily were averaged for each weekly period. Cumulative energy balance was calculated as the sum of the average weekly energy balances. This was phase I of the analyses and consists of Figures 1-16 in the Results section.

Phase II.

General Linear Models of SAS statistical software was used to analyze the effects of energy balance, milk production an dry cow dietary treatment on serum metabolites, milk yield, body weight change, TDN intake, energy balance and cumulative energy balance. Cows were assigned classification variables as before for milk production (high versus low milk yield in the previous lactation), and dry cow dietary treatment (110% versus 160% of NRC requirements for energy). In addition cows were classified on the basis of cumulative energy balance (cows above and below -50 Mcal cumulative negative energy balance). The study was undertaken to define relationships between milk production, energy balance and dry cow feeding on blood hormones, weight change, and energy balance during the dry and lactating period. If possible, these relationships would be related to reproductive potential with time postpartum.

The statistical model was a general linear model for repeated measures (SAS). The form of the model was as follows:

$$Y_{ijk} = \mu + Grp_i + Cow(Grp)_{ijk} + Wk_k + Grp*WK_{ij} + residual$$

Y = dependent value for the ith group from the jth cow in the kth week.

μ = mean value

Grp = group coded 1 or 2 (classification group).

Separate models were run for the three groups: production, dry cow dietary treatment, and cumulative energy balance groups. Separate models were run for the dry and lactating periods.

Cow(Grp) = repeated samples from each cow at each week each cow was associated with a group classification and a week of sampling.

Wk = kth week

Grp*Wk = Interaction of Group*Week

Residual

To test the significance of group effects, the error term used was group nested within cows. The residual was used to test for any significant interaction between group and week. Least square means are reported in Tables 1 through 6 for each of the groups.

RESULTS AND DISCUSSION

Phase I.

Phase I simply is an attempt to reduce the mass of numbers to a visual portrayal of trends. The Figures 1-16 all have weight included as a baseline. Figures 1-4 deal with the low producing cows fed 110% of NRC recommendations during the dry period. Figures 5-8 represent the low producing cows fed 160% of NRC recommendations during the dry period. Figures 9-12 and 13-16 represent high producing cows fed, respectively 110 and 160% of NRC recommendations during the dry period. Each graph compares two different variables over a period from 28 days (4 weeks) before calving to 105 days (15 weeks) after calving. Obviously certain variables, such as milk production, are only graphed after parturition.

These graphs primarily are for perusal to gain familiarity with the data obtained. Expected shifts in body weight were obtained. In several cases hormone patterns followed changes in body weight soon after calving. These relationships will be discussed under the phase II analysis where the least squares estimates and the standard errors of the mean (SEM) are presented.

Phase II.

Data in phase II are summarized in Tables 1-6. Each table has least squares means and their standard errors (SEM) for the various traits measured or calculated. The tables start with data obtained in the last 4 weeks of the dry period (weeks -4, -3, -2, and -1) and continue for a maximum of 24 weeks postpartum. Results will be discussed in pairs of tables as Tables 1 and 2 give results for cows classified into two cumulative energy balance groups, Tables 3 and 4 give data for cows grouped on milk produciton and Tables 5 and 6 comprise cows grouped by the feeding regimes of 110 and 160% of NRC standards during the dry period. The second table in each set (Tables 2, 4 and 6) include a summary of the analyses of variance for both the dry period and the lactation period.

Cumulative Energy Balance (Tables 1 and 2).

Cows were categorized into two cumulative energy balance groups (CEB): 1. cows which did not exceed -50 Mcal CEB; 2. cows which exceeded -50 Mcal CEB. Cows which exceeded -50Mcal CEB were found to be subfertile (first service CR below 40%) even when first service was more than 90 days postpartum. A similar trend was detected also for second service conception rates. Thus cows were categorized into these CEB groups to examine differences in blood hormones, milk yield, body weight change, and energy balance.

During the dry period, cows which exceeded -50 Mcal CEB tended to have elevated serum bovine growth hormone (BGH) compared to cows which did not exceed -50 Mcal CEB (2.94 vs 1.80 ng/ml, $p<.01$, respectively). Cows which exceeded -50 Mcal CEB also were heavier ($p<.01$) than the other cows (595 vs 567 kg, respectively). Otherwise there were no differences in serum insulin, T3, T4, or TDN intake in the dry period.

After calving there were significant differences in serum insulin, fat corrected milk yield (FCM), and, naturally, energy balance (EB) and CEB, $p<.01$. Serum insulin was lower in cows with more negative CEB (6.24 vs 8.29 μU/ml, respectively); FCM yields were higher (30.5 vs 25.3 kg, respectively).

There were significant ($p<.05$) group by week interactions for T3, T4, FCM, body weight, TDN intake, EB, and CEB. Cows more negative in CEB had higher peak yields of milk with normal lactation declines, in the lactation curve, whereas cows with less negative CEB had lower yields of peak milk and flatter lactation curves. Cows more negative in CEB incurred increased weight loss for longer periods compared with cows with less negative CEB. TDN intake was the same for the first 11 weeks of lactation for both groups of cows. However, after week 11 of lactation, cows with more negative CEB had higher intakes of TDN, probably reflecting the higher milk production by these animals. Similar intakes of TDN by cows with higher yields of milk in the first 11 weeks of lactation resulted in more weight loss and more negative EB. This resulted in the more negative CEB in these cows. Serum concentrations of T3 and T4 were lower for the first 11 weeks postpartum in cows with more negative CEB compared with cows not as negative, but then were higher from week 12 to 15.

Of special interest in these two groups of cows differing markedly in energy balance is the reproductive performance. Group I, with a cumulative energy balance of 0 to -50 Mcal, had a 59% pregnancy rate on first service, and in Group II, with more than -50 Mcal cumulative energy balance, 38% conceived. There was an important interaction (p=0.056) between time of conception postpartum and the grouping.

Time conceived postpartum	Pregnancy rate at first service in: Group I	Group II
< 90 days	30%	43%
> 90 days	83%	36%

The cows which were able to balance intake and output of energy to minimize the negative cumulative energy balance had the ability to recover and respond positively to breeding after 90 days postpartum. The animals in the group with the greater negative energy balance were unable to recover as well. It is of considerable importance management-wise to be able to identify early those animals which are likely to have prolonged problems. In this study blood insulin was significantly lower (p<0.01) in the group with the greater negative energy balance. This was consistent throughout the early postpartum period. Thus, blood sampling with hormone analysis early in the postpartum period should be useful in focusing attention on cows likely to require different nutritional strategies for the most economical production and reproduction.

Production Group (Tables 3 and 4).

Higher producing cows were heavier in the dry period than lower producers (705 vs 636 kg, respectively). No other differences were noted in the dry period.

Higher producing cows gave more milk (31.2 vs 23.9 kg, $p<.01$, respectively), lost more body weight for a longer time, and consumed more TDN ($p<.01$). An example of the latter means for high and lower producing groups are 31.4 and 28.5 Mcal, respectively. Higher production was associated with increased negative EB and more negative CEB compared with lower producing cows ($p<.01$), but EB and CEB did not become as negative as they were for cows in the higher CEB group. Thus milk production alone does not account for total negative energy balance. Factors decreasing feed intake may predispose some animals, regardless of production, into more negative EB and CEB than would normally be expected.

During lactation, the only hormones influenced by production were T_3 and T_4. Higher producing cows compared to lower producers had lower T3 and T4 throughout the first 15 weeks of lactation ($p\leq.01$). There were no differences in serum insulin or growth hormone concentrations. Insulin tended to be lower (6.92 vs 7.94 μU/ml, $p<.11$) in higher producers than in lower producers.

Dry Cow Feeding Groups (Tables 5 and 6).

The dry cow feeding program influenced serum insulin, T3, T4 and TDN intake during the dry period ($p<.05$). The higher energy diet compared to the lower energy diet was associated with increased serum T3 (2.07 vs 1.64 ng/ml, $p<.05$, respectively), T4 (3.91 vs 3.05 μG/dl, $p<.01$), respectively), and insulin (11.69 vs 8.42 μU/ml, $p<.05$, respectively). Body weight tended to be higher in the dry period in cows receiving the higher energy diets (686 vs 655 kg, $p<.2$, respectively).

There were no significant effects ($p>.10$) of dry cow feeding on serum hormones, FCM, body weight, TDN intake, EB or CEB during lactation.

4. Conclusions

Although similar in milk yield, body weight change, energy balance, and cumulative energy balance, categorizing cows by production group was not identical to categorizing cows by CEB (Tables 1, 2). There were different patterns in serum insulin, T3, T4, and TDN intake. The primary factor influencing the difference between the high production group and the more negative CEB group was the rate of increase of TDN intake after calving. Higher producing cows tended to eat more TDN than lower producing cows in the first 11 weeks of lactation, whereas more negative CEB cows ate the same amount of TDN as the less negative CEB cows, despite giving over 5 kg more milk per day. This may be why changes with time postpartum for serum insulin, T3 and T4 were slightly different between cows ranked as high producers.

Higher levels of milk production (Tables 3, 4) were associated with more negative energy balance. Cows with more negative energy balance, had higher yields of milk, and lower levels of serum insulin, T3 and T4. They lost more body weight over longer periods of time than cows which in CEB or those cows which give less milk. A striking difference between cows with more negative CEB and cows ranked as high producers was the difference in TDN intakes. This resulted in increased negative CEB and lower serum insulin in the negative CEB cows than in the high producing cows. How changes in insulin, T3 and T4 early in the postpartum period may influence fertility later is not clear, but it is important to study as insulin, especially, appeared to be a predictor of reproductive problems with major negative energy balances.

High producing cows were heavier at calving than lower producers. Higher body weights may be due to larger frame size and/or more body adipose tissue. Larger frame size would be associated with greater gut capacity and higher capacity for dry matter intake, supporting more milk through nutrient intake. Higher condition due to increased adipose stores would provide more tissue to be mobilized for energy utilization early in the postpartum period, supporting higher levels of milk yield, but increasing negative EB. Cows classed as high producers tended to consume more TDN earlier than cows classed as more negative in CEB, despite yielding similar amounts of milk per day (31.2 vs 30.5 kg, respectively). Body weights were similar between classification groups. Possibly frame size was different, resulting in lower TDN intake in the first 11 weeks of lactation in more negative CEB cows than high producing cows.

Level of dry cow feeding (Tables 5, 6) appeared to have little influence on postpartum serum hormones values, milk yield, feed intake, or body weight change in third lactation animals. During the dry period serum insulin, T3 and T4 were increased by the higher energy diet. These appeared to have no effect on postcalving performance.

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FIGURE 1. Low prod., 110%

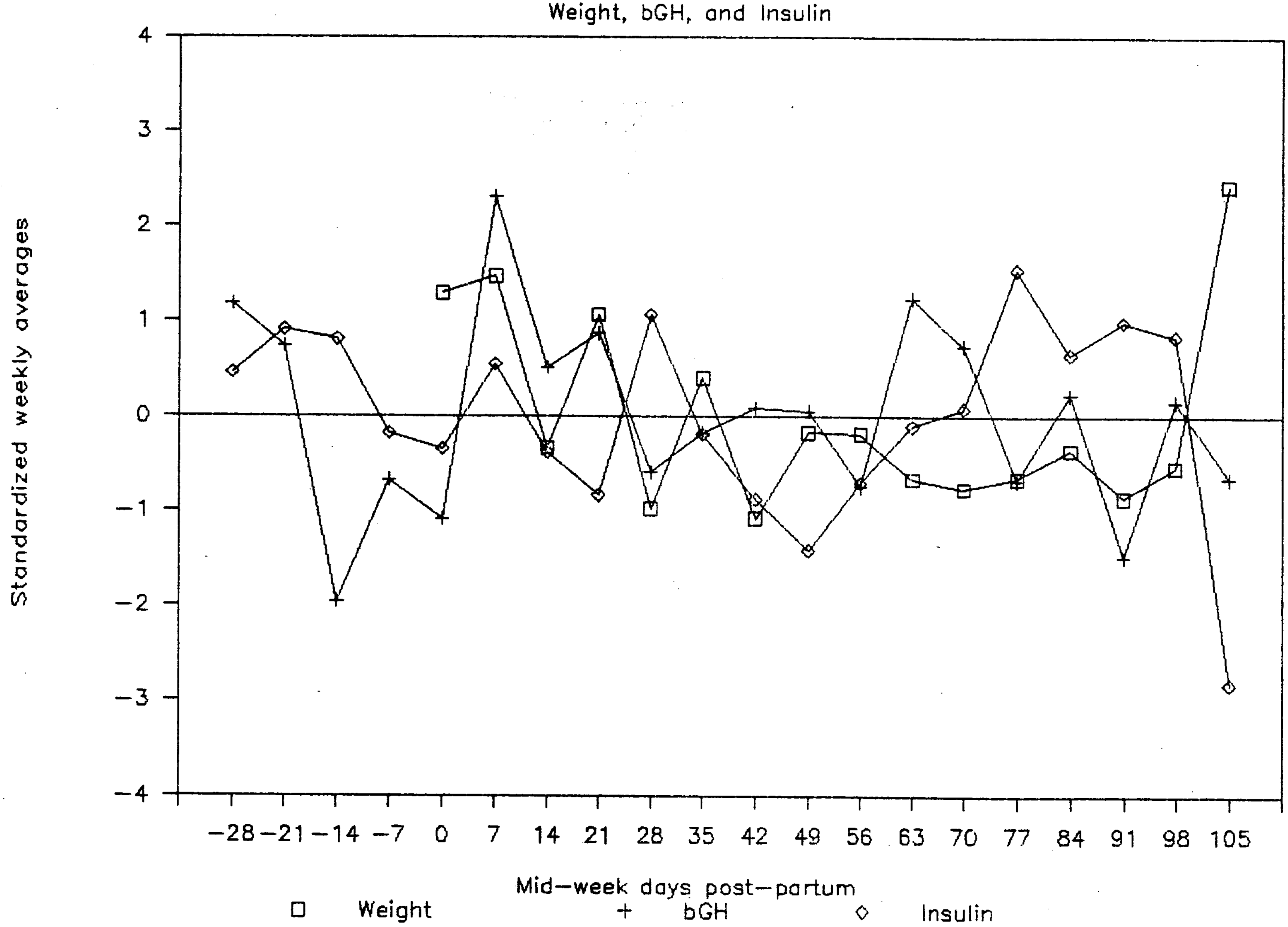


FIGURE 2. Low prod., 110%

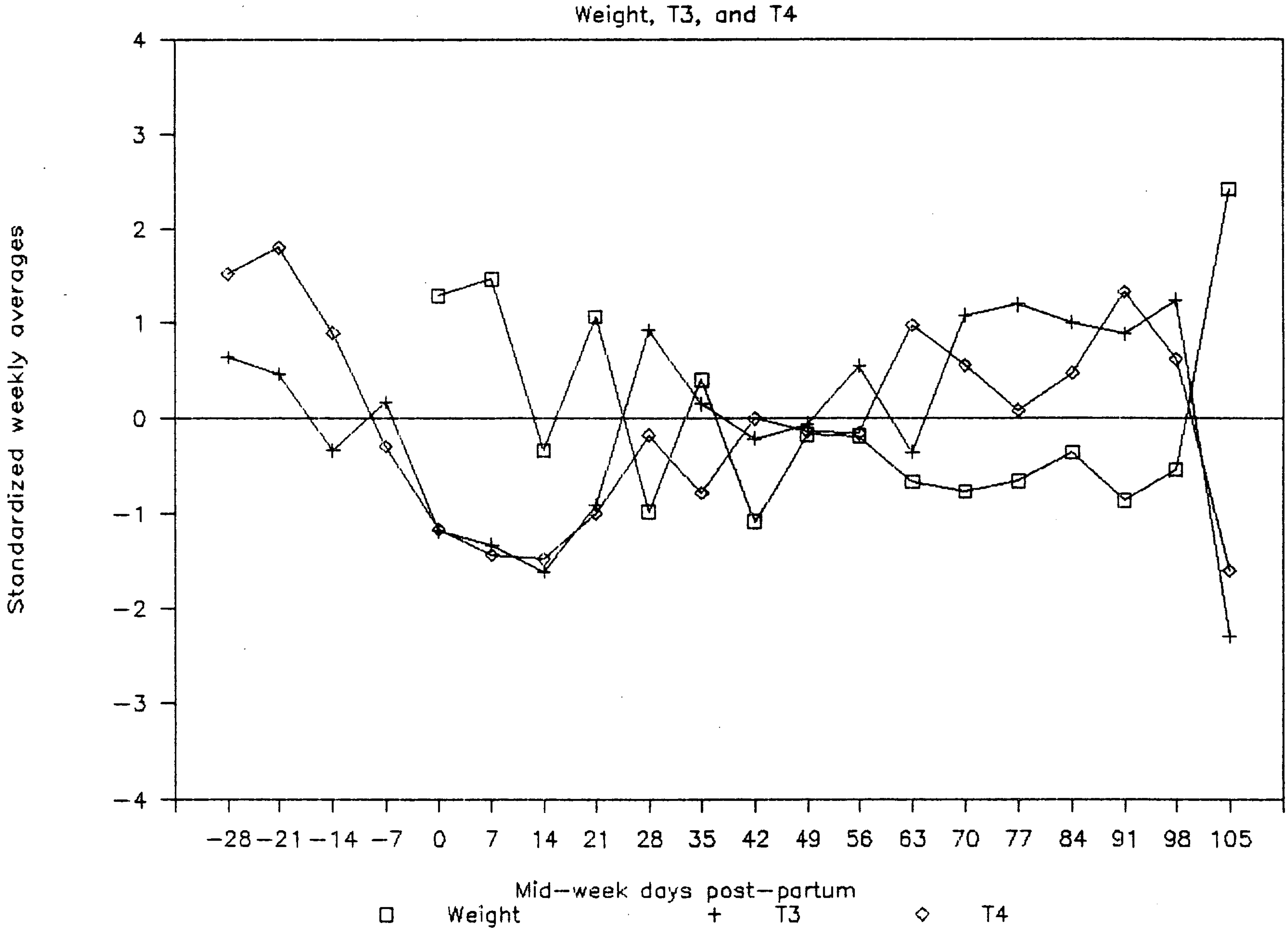
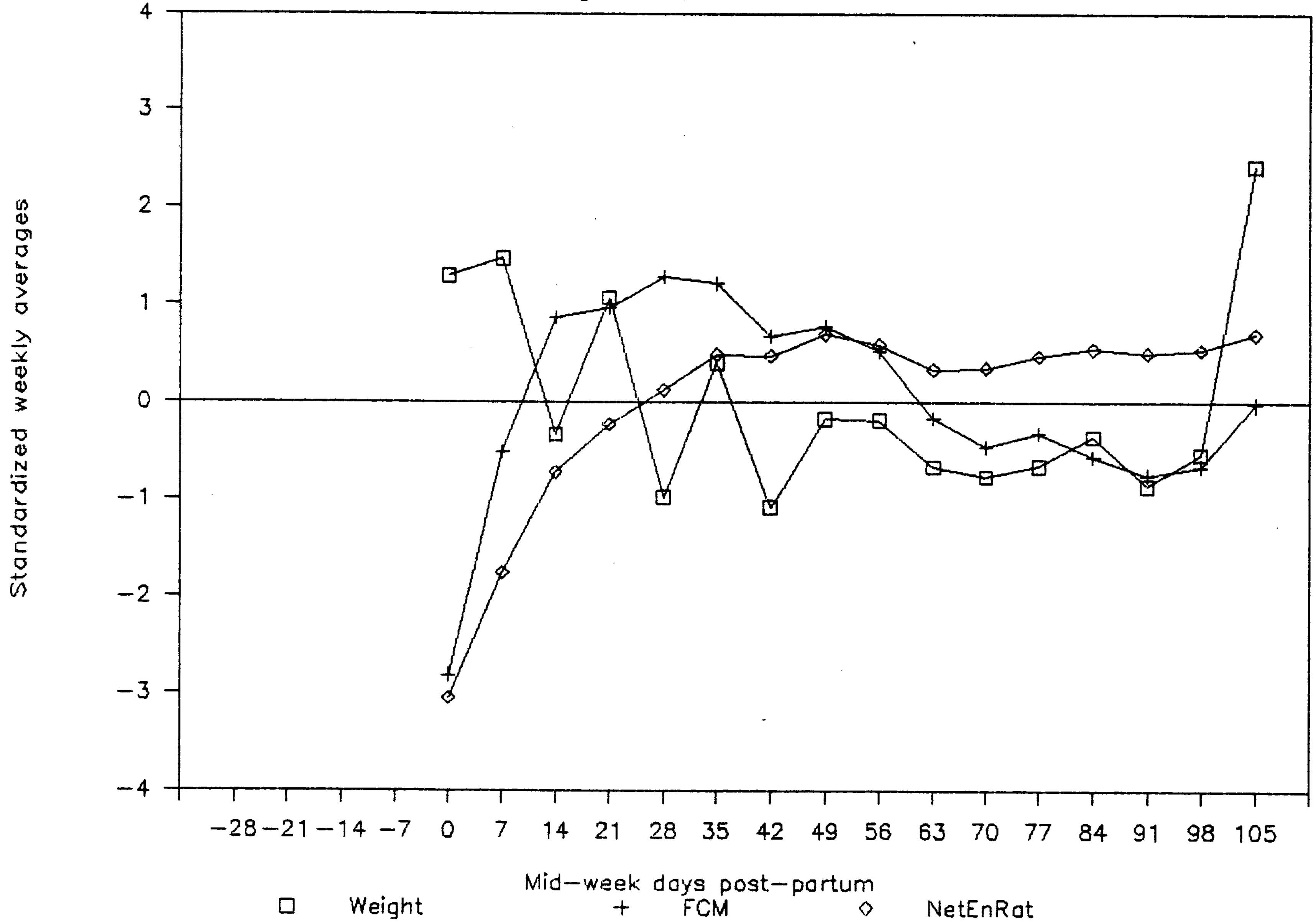


FIGURE 3. Low prod., 110%

Weight, FCM, and NetEnRat



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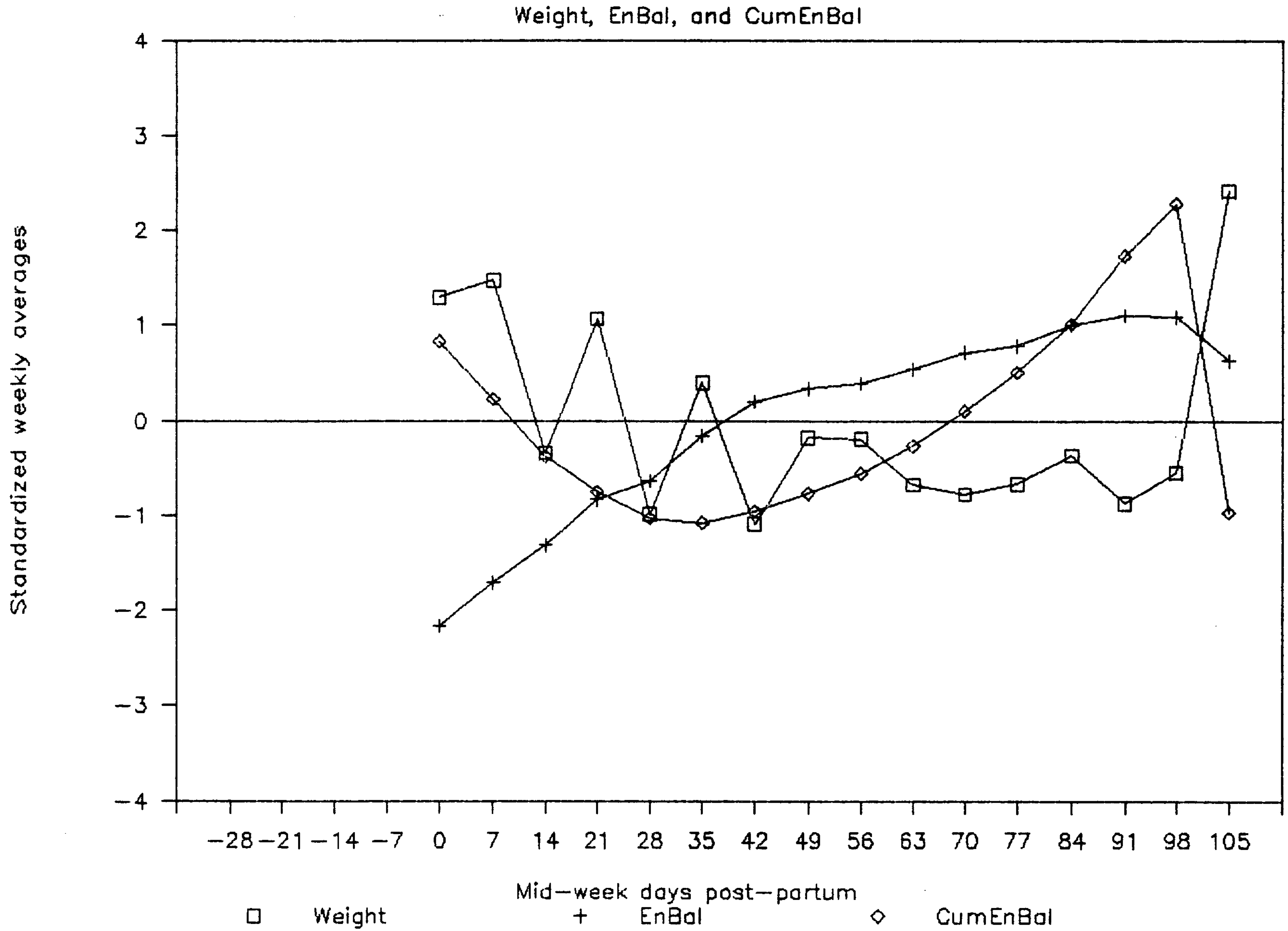


FIGURE 5. Low prod., 160%

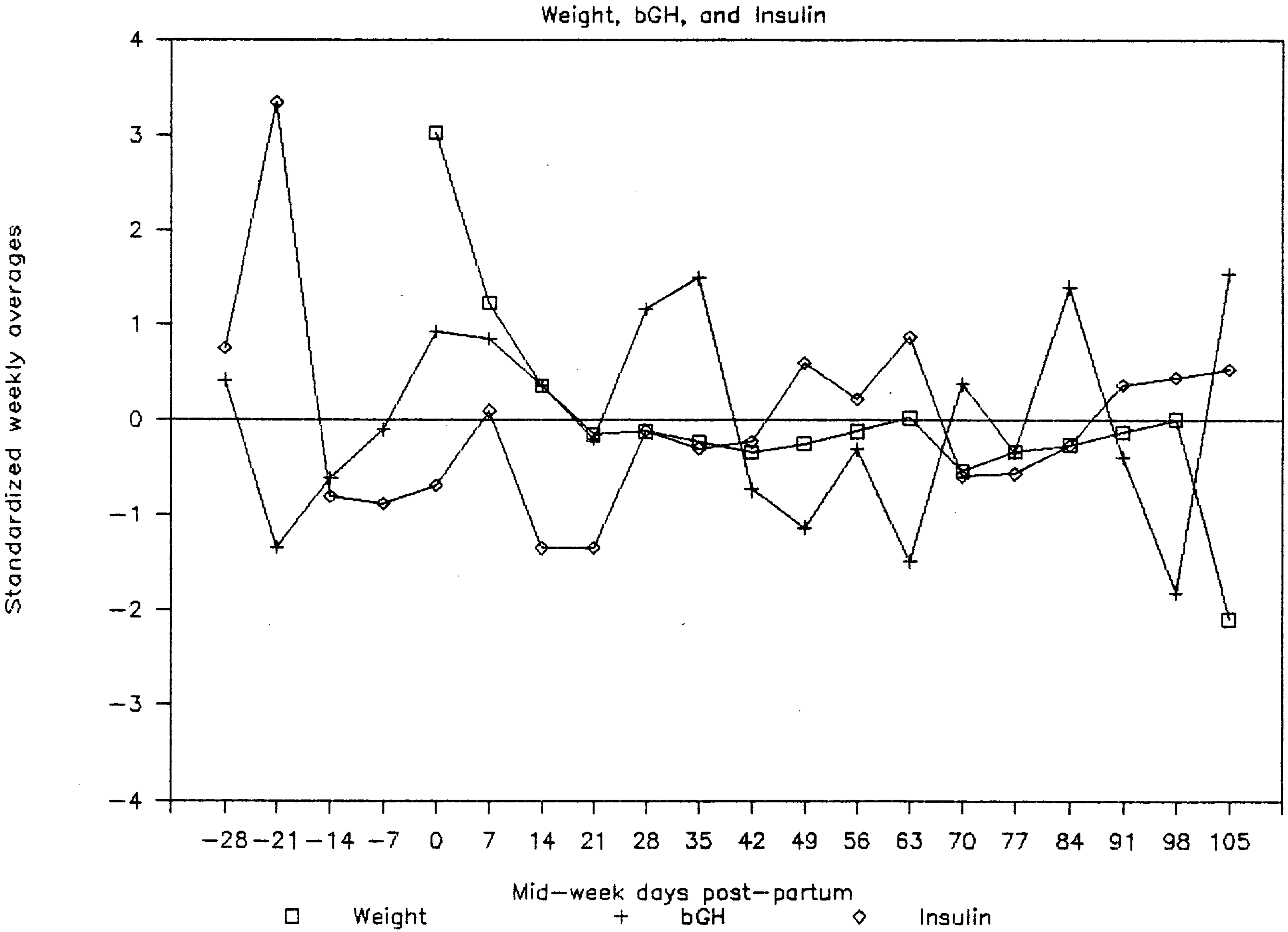


FIGURE 6. Low prod., 160%

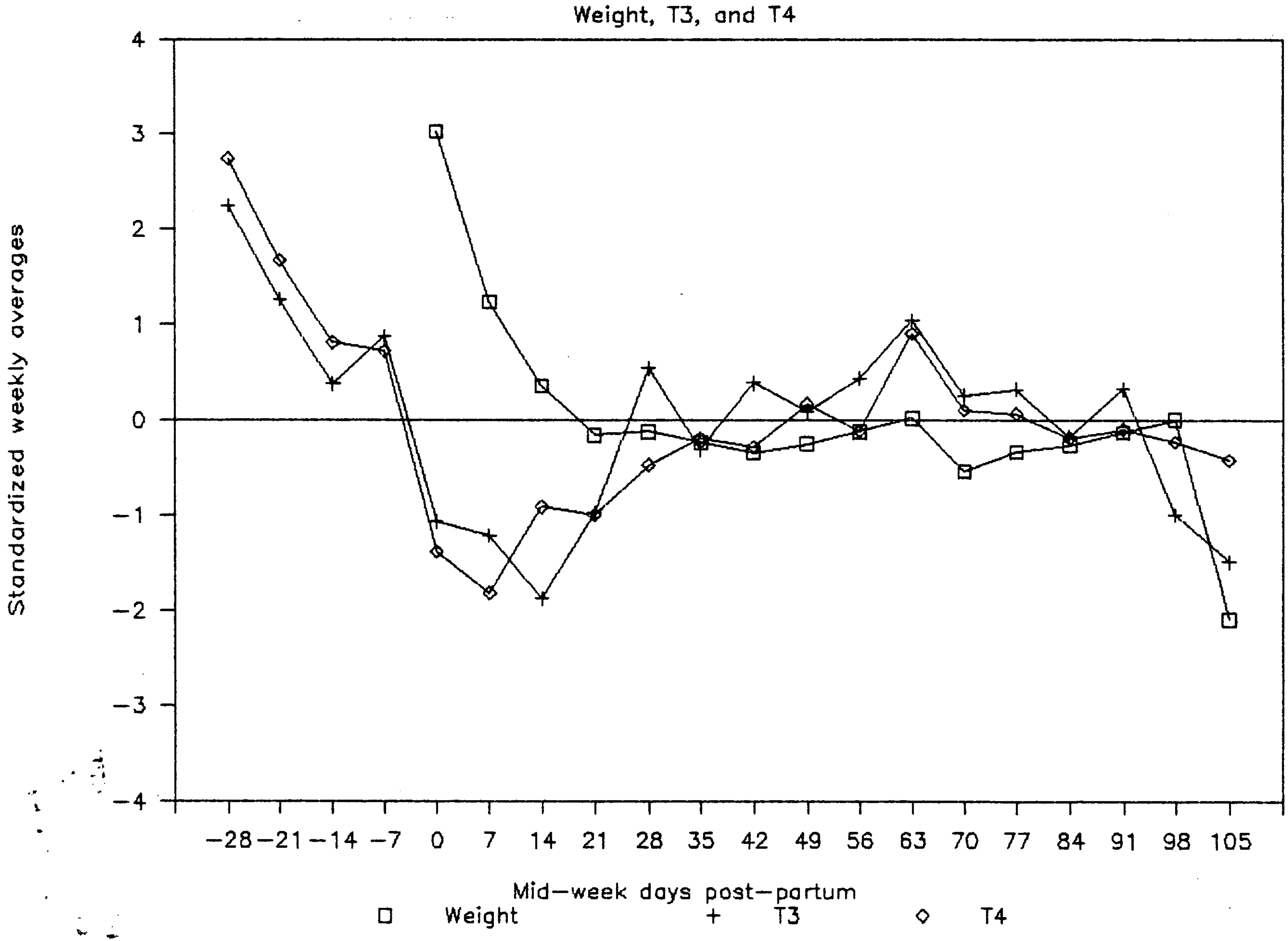
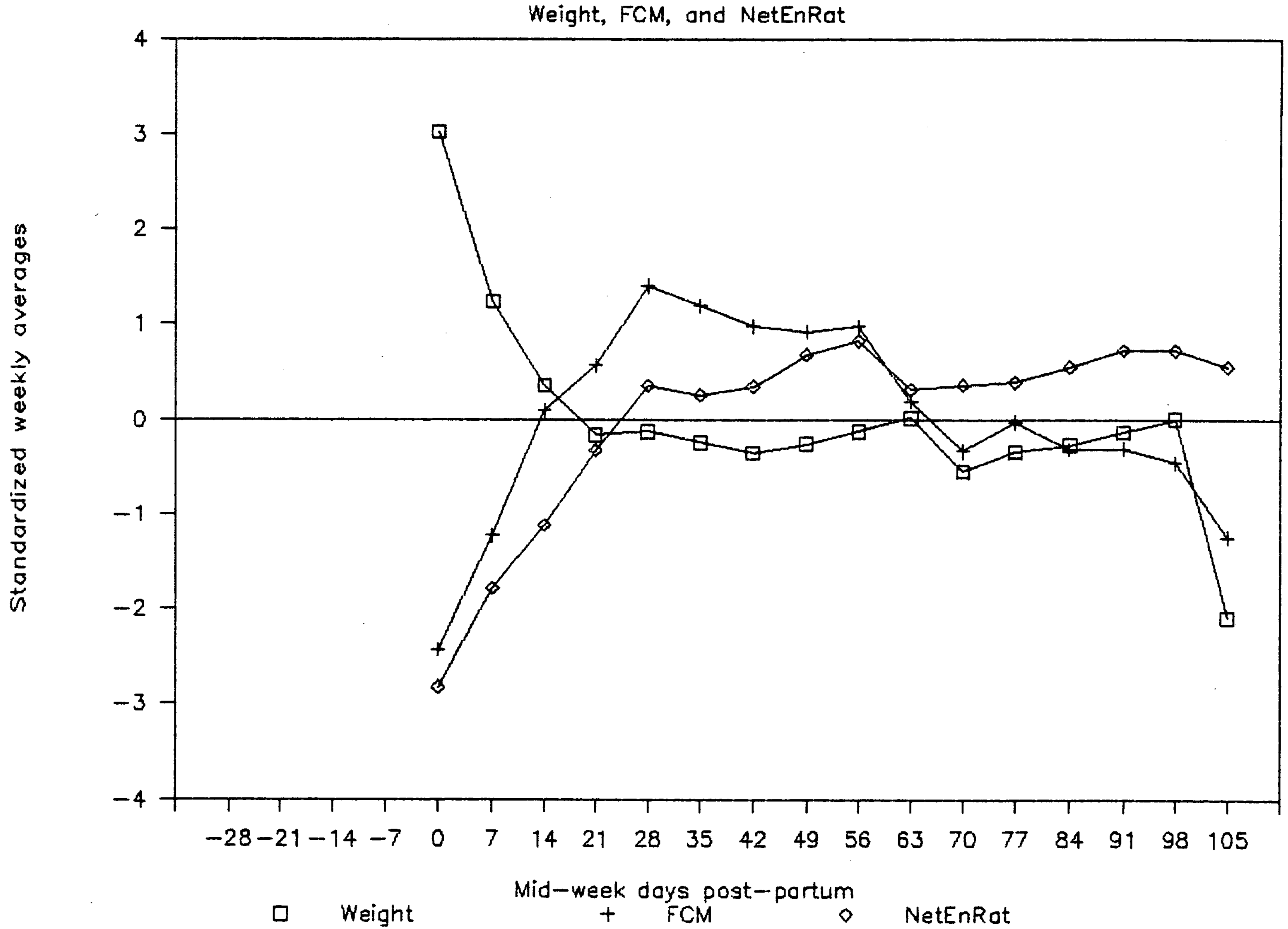


FIGURE 7. Low prod., 160%



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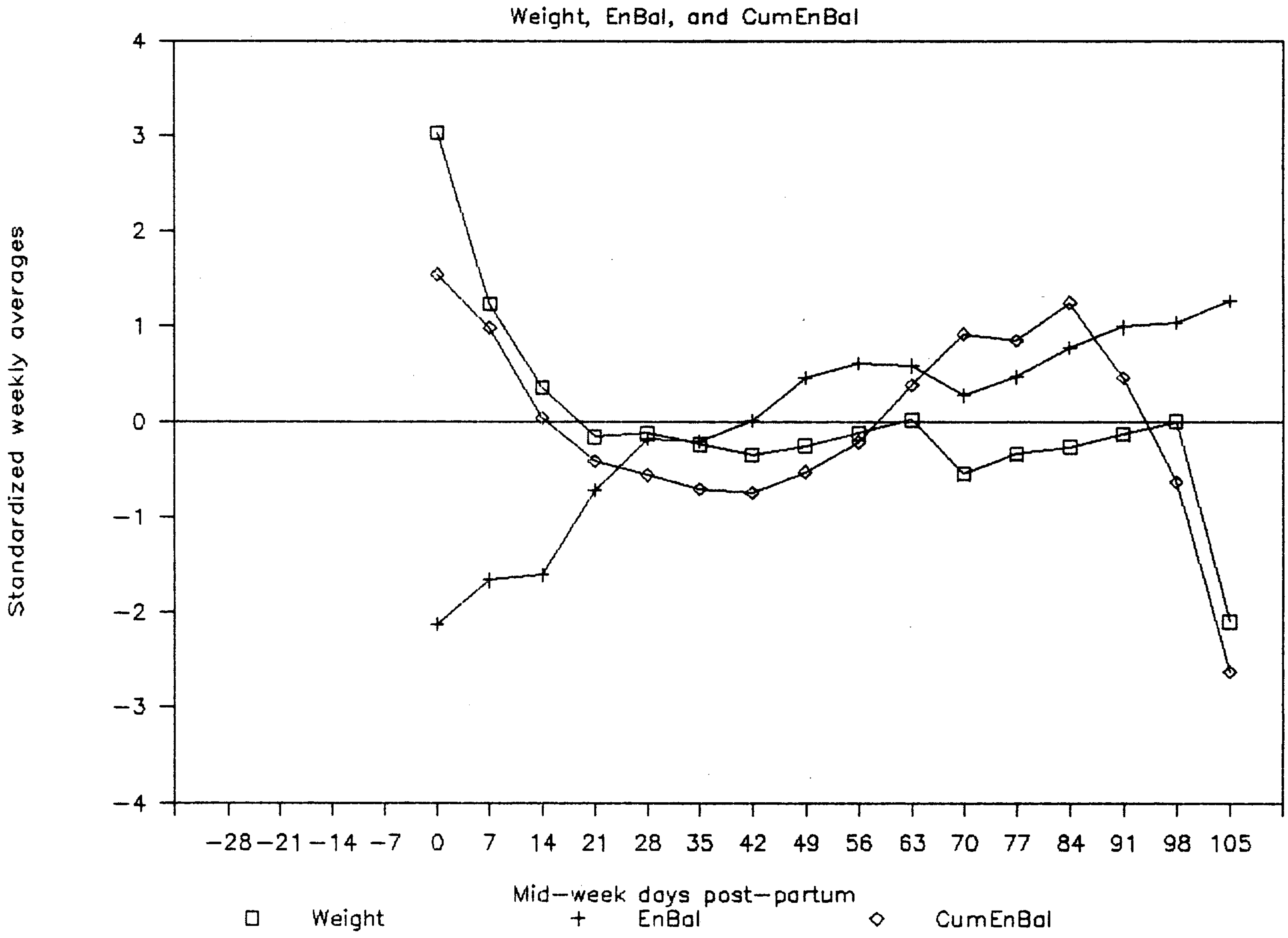

FIGURE 9. High prod., 110%

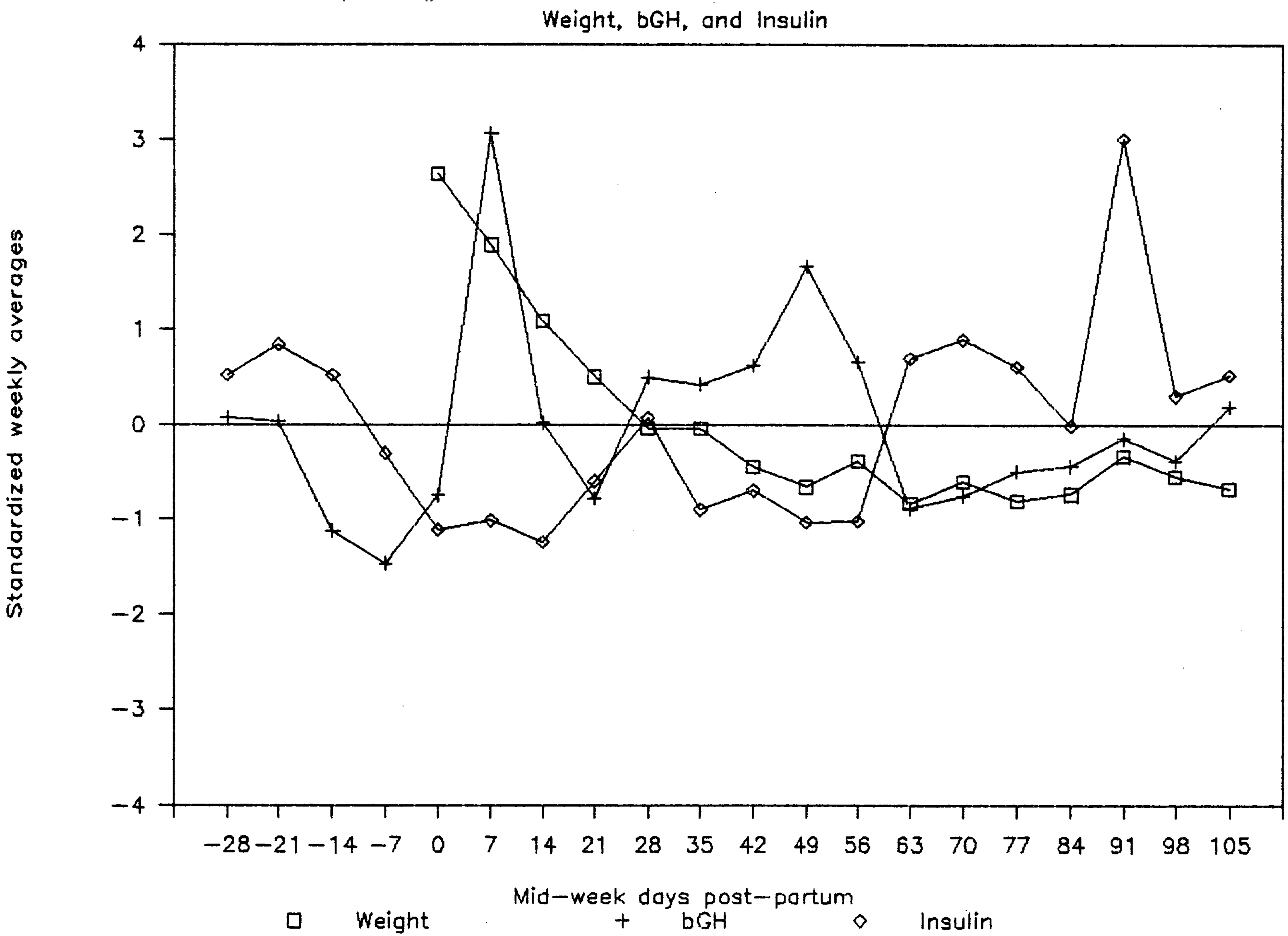

FIGURE 10. High prod., 110%

Weight, T3, and T4

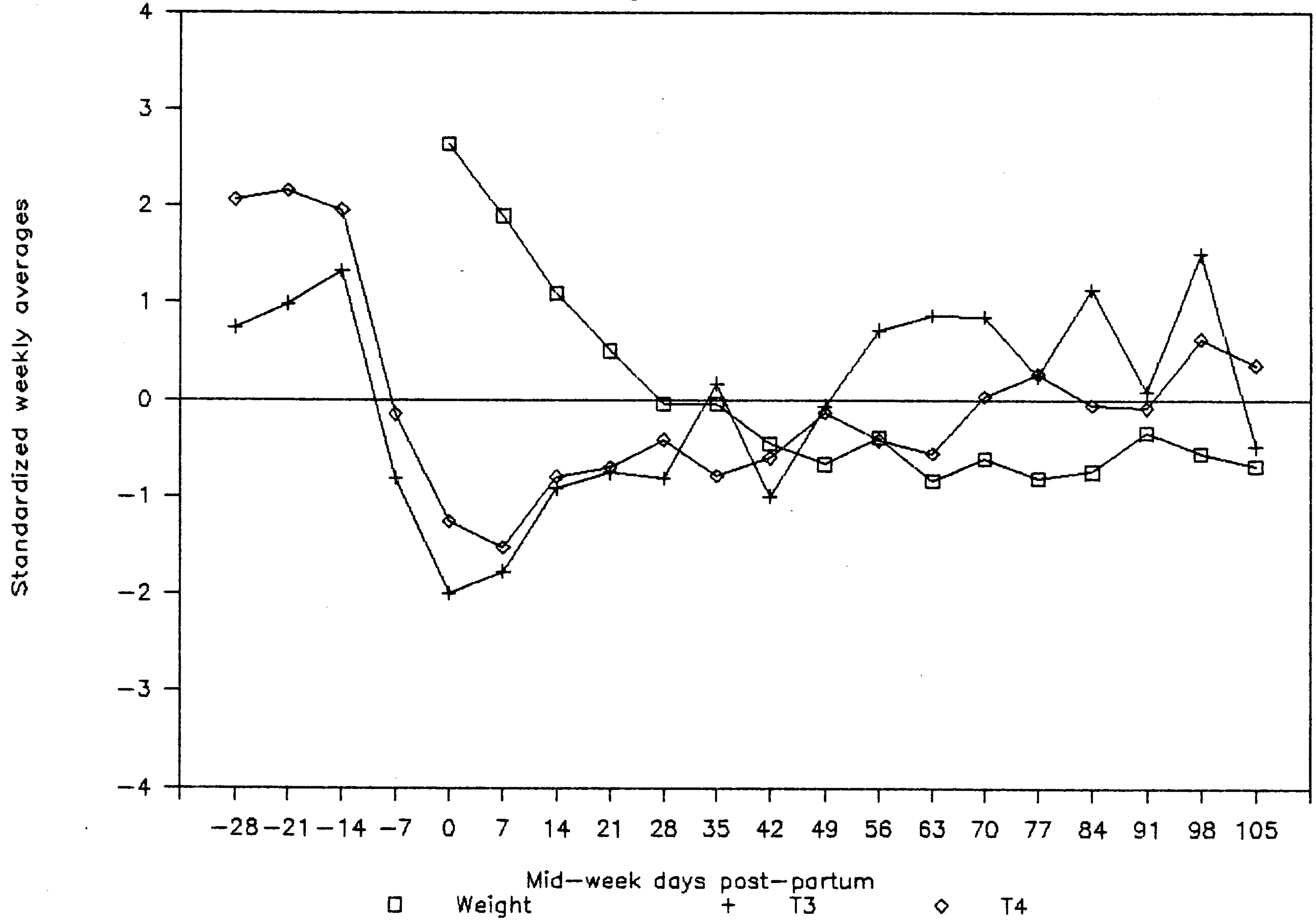

FIGURE 11. High prod., 110%

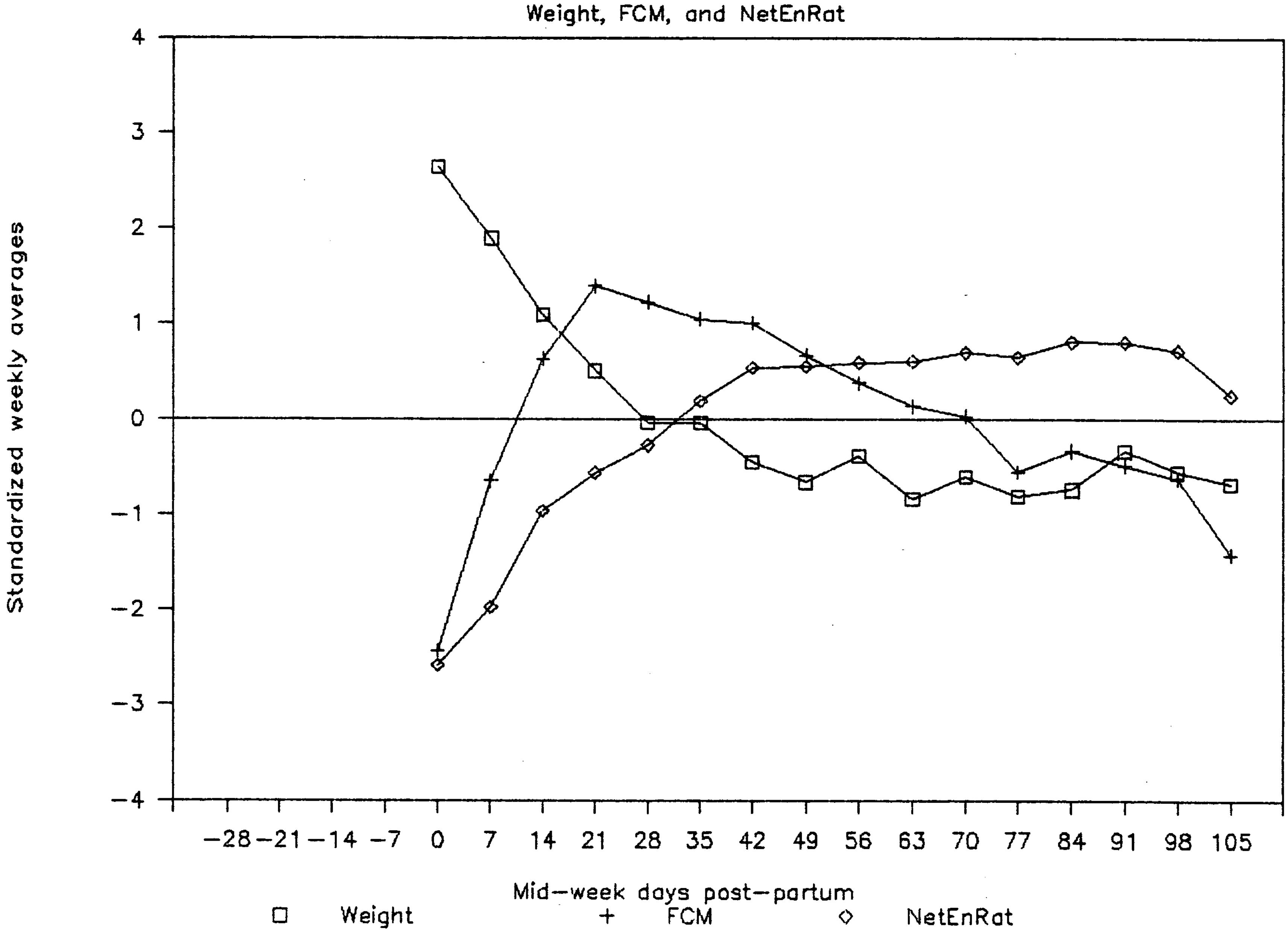

FIGURE 12. High prod., 110%

Weight, EnBal, and CumEnBal

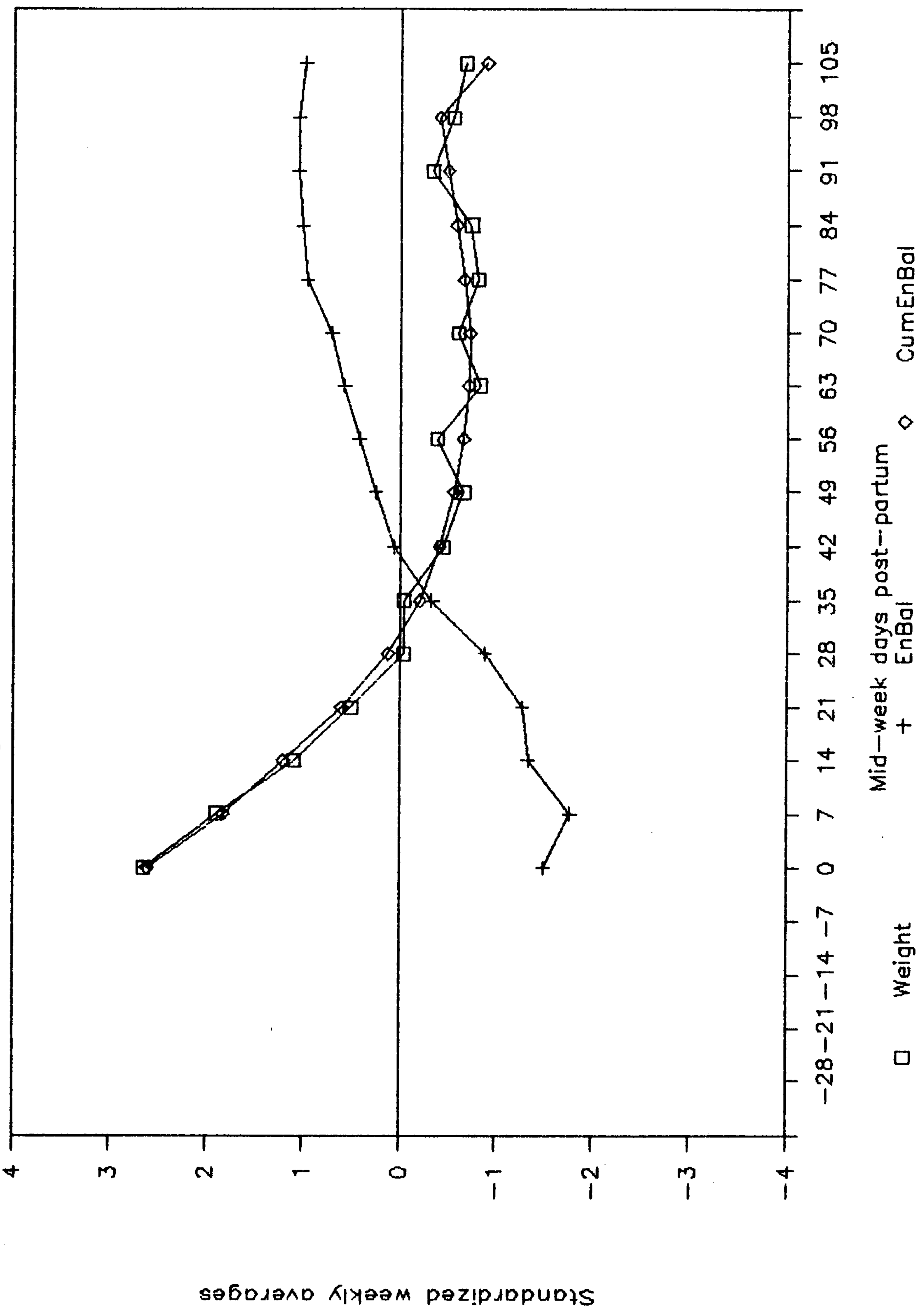

FIGURE 13. High prod., 160%

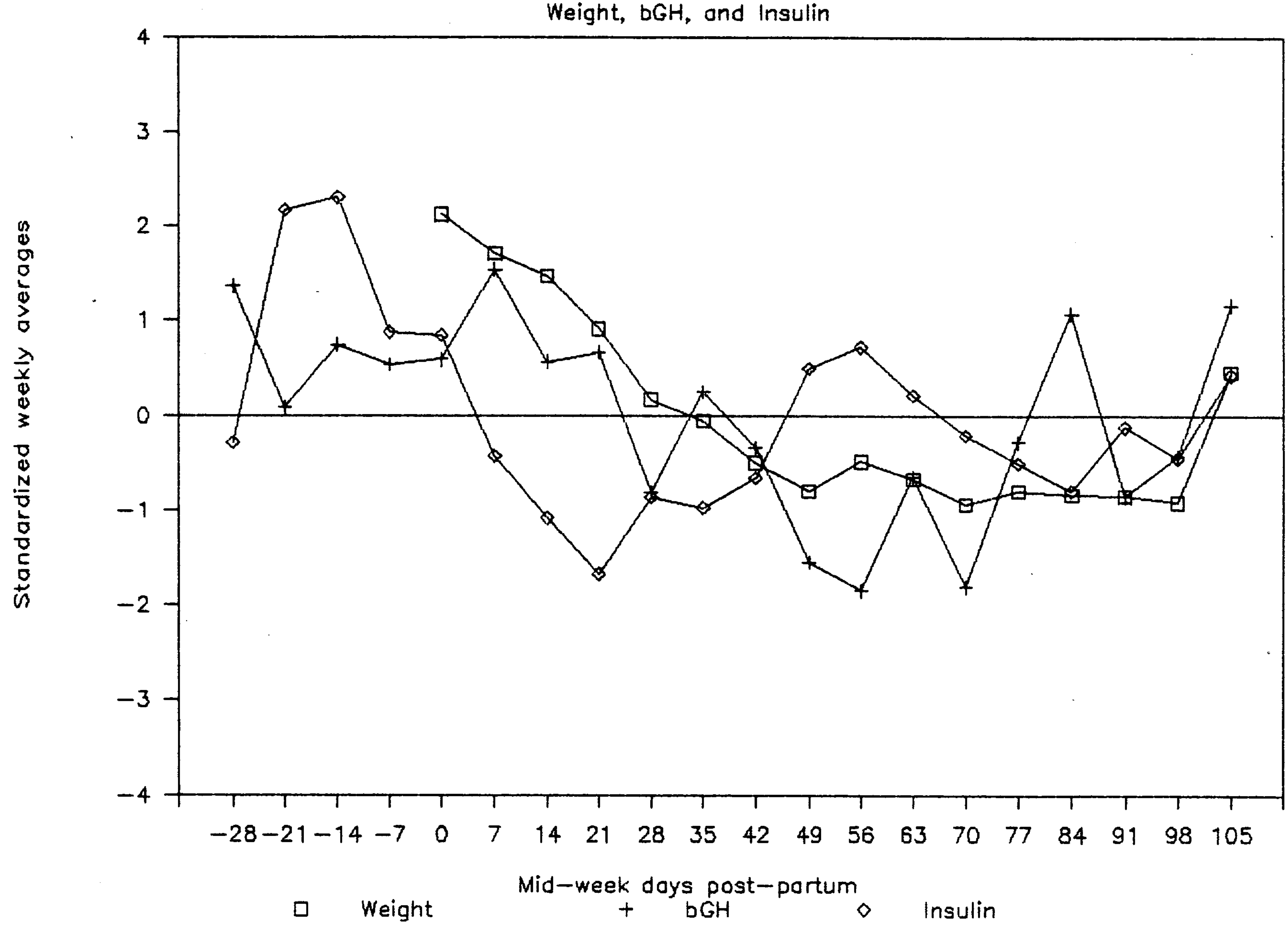

FIGURE 14. High prod., 160%

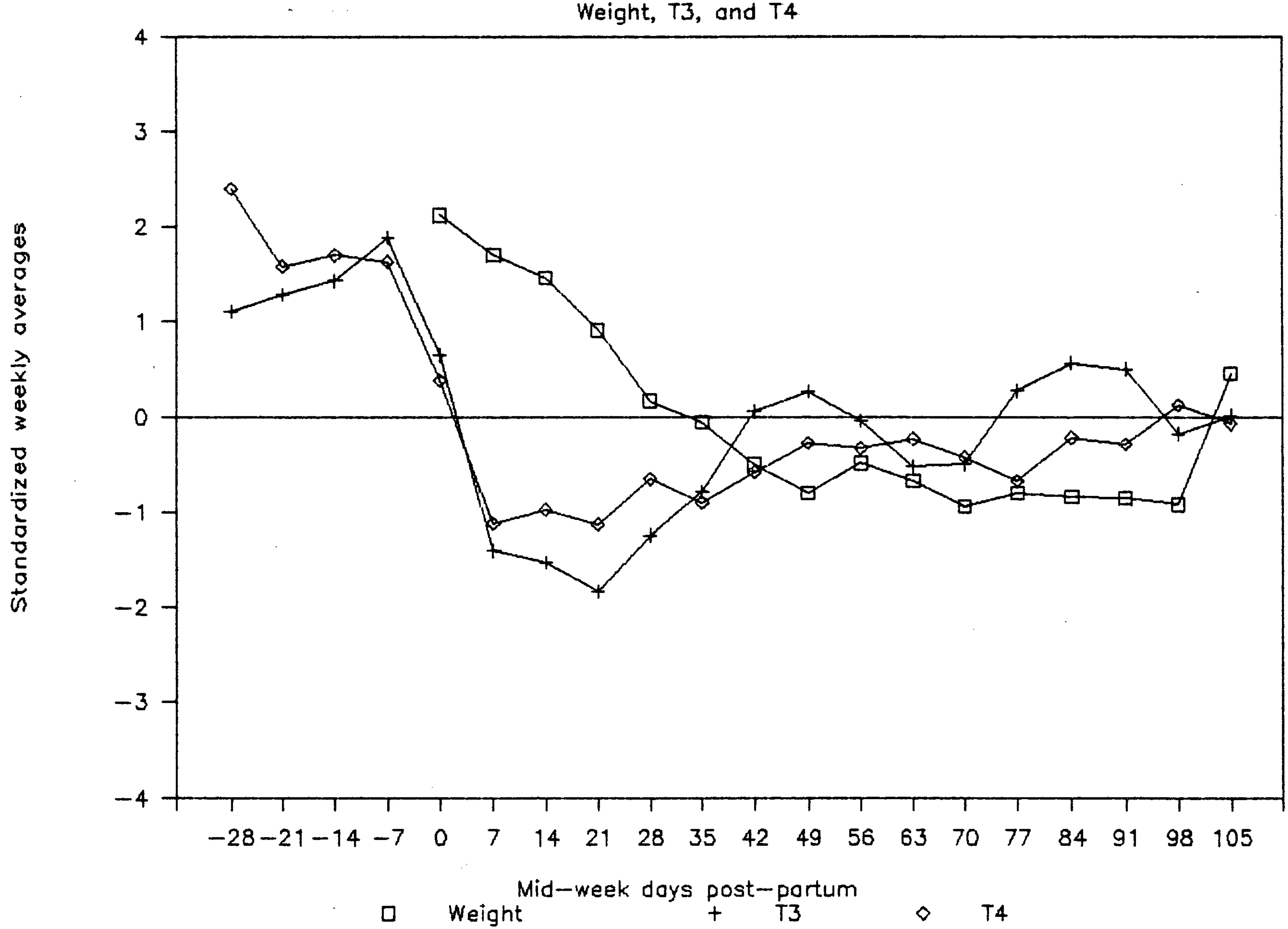

FIGURE 15. High prod., 160%

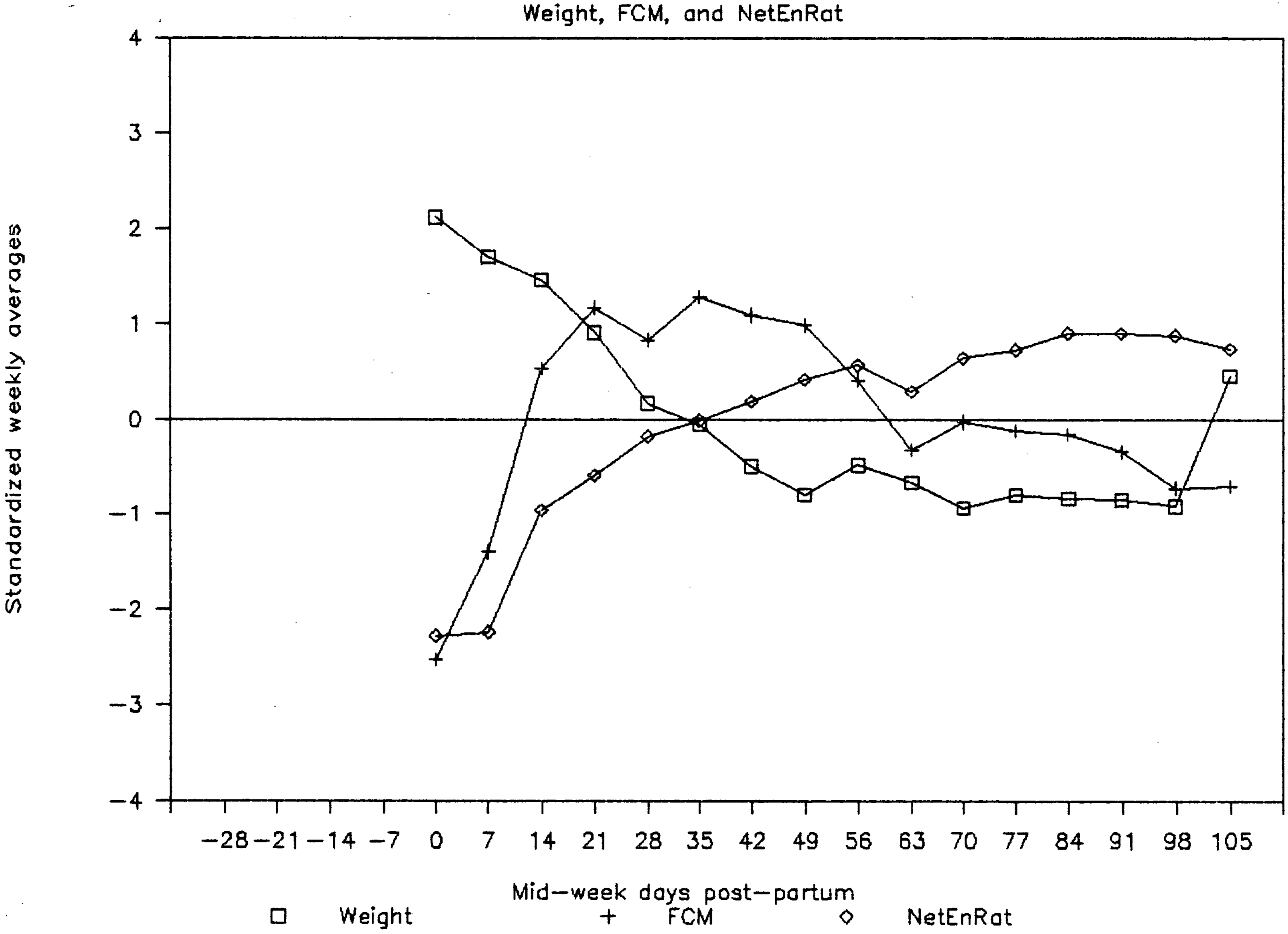

FIGURE 16. High prod., 160%

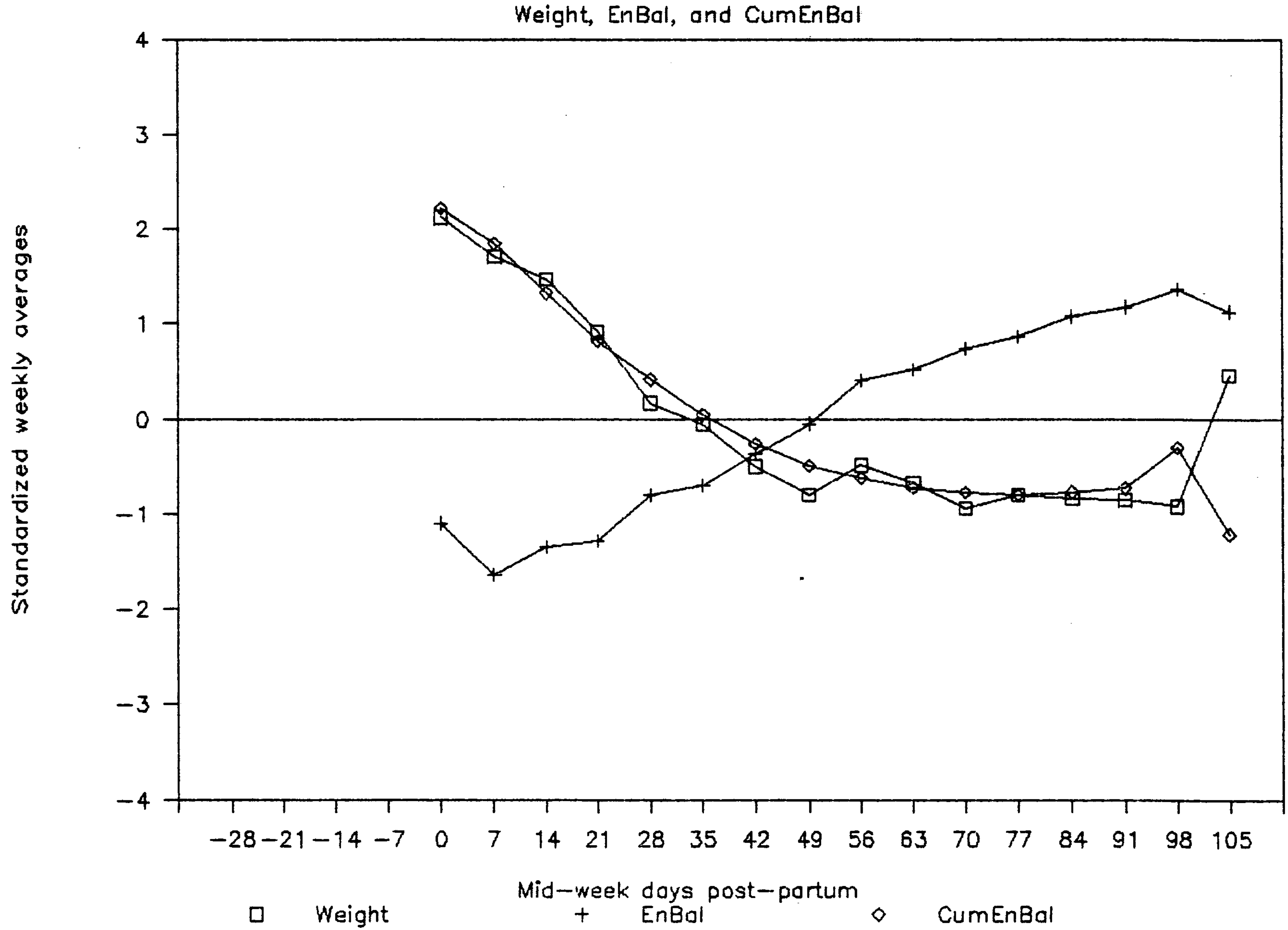

TABLE 1

ENERGY BALANCE GROUP - 0 TO -50 MCAL CUMULATIVE ENERGY BALANCE - GRP 1

LEAST SQUARE MEANS

WK LAC	BGH (ng/ml)	SEM	INS (uU/ml)	SEM	T3 (uG/dl)	SEM	T4 (uG/dl)	SEM	FCM (kg)	SEM	WT (KG)	SEM	TDNRAT (Mcal)	SEM	EBAL (Mcal)	SEM	CUMEBAL (Mcal)	SEM
-4	1.85	0.52	13.26	1.25	1.96	0.09	3.98	0.16	- --	--	629	2.1	18.08	0.66	- --	--	- --	--
-3	2.08	0.52	11.63	1.21	1.79	0.08	3.83	0.17	- --	--	639	2.1	17.81	0.66	- --	--	- --	--
-2	1.49	0.55	8.31	1.32	1.80	0.09	3.33	0.18	- --	--	645	2.1	17.53	0.66	- --	--	- --	--
-1	1.78	0.53	8.72	1.28	1.69	0.09	2.62	0.17	- --	--	656	2.1	13.81	0.66	- --	--	- --	--
LSMEAN	1.80	0.27	10.48	0.63	1.81	0.04	3.44	0.09			642	1.0	16.81	0.33				

WK LAC	BGH (ng/ml)	SEM	INS (uU/ml)	SEM	T3 (uG/dl)	SEM	T4 (uG/dl)	SEM	FCM (kg)	SEM	WT (KG)	SEM	TDNRAT (Mcal)	SEM	EBAL (Mcal)	SEM	CUMEBAL (Mcal)	SEM
1	2.29	0.55	9.95	1.10	1.54	0.09	2.22	0.14	20.2	0.59	593	7.2	20.21	0.63	-4.31	0.52	-4.31	2.73
2	3.89	0.55	6.84	1.08	1.24	0.09	1.96	0.14	26.0	0.59	578	7.2	23.90	0.63	-4.76	0.52	-9.07	2.73
3	3.35	0.52	6.65	1.05	1.56	0.09	2.32	0.13	28.1	0.59	568	7.2	26.44	0.63	-3.60	0.52	-12.67	2.73
4	2.75	0.55	6.10	1.10	1.44	0.09	2.06	0.14	29.1	0.59	565	7.2	27.99	0.63	-2.73	0.52	-15.40	2.73
5	2.79	0.54	9.86	1.08	1.72	0.09	2.71	0.14	29.3	0.59	563	7.2	29.26	0.63	-1.61	0.52	-17.01	2.73
6	3.26	0.56	6.79	1.10	1.62	0.09	2.46	0.14	28.8	0.59	561	7.2	30.12	0.63	-0.42	0.52	-17.43	2.73
7	2.54	0.52	6.93	1.05	1.70	0.09	2.72	0.13	28.6	0.59	561	7.2	30.55	0.63	0.24	0.52	-17.19	2.73
8	2.04	0.54	8.70	1.08	1.77	0.09	2.52	0.14	28.3	0.59	562	7.2	31.60	0.63	1.42	0.52	-15.77	2.73
9	2.55	0.52	8.70	1.05	1.80	0.09	2.96	0.13	27.7	0.59	567	7.2	31.33	0.63	1.52	0.52	-14.25	2.73
10	2.15	0.54	8.01	1.05	1.86	0.09	2.92	0.14	26.4	0.59	562	7.2	31.00	0.63	2.28	0.52	-11.97	2.73
11	2.70	0.54	7.97	1.10	1.86	0.09	2.77	0.14	26.2	0.59	563	7.2	31.28	0.63	2.66	0.52	-8.76	2.73
12	2.03	0.55	9.66	1.08	1.72	0.09	2.67	0.14	26.6	0.59	563	7.2	31.28	0.63	2.43	0.52	-6.94	2.73
13	3.08	0.52	7.88	1.05	1.69	0.09	2.68	0.13	26.2	0.59	567	7.2	31.80	0.63	3.12	0.52	-3.82	2.73
14	2.04	0.58	10.18	1.13	1.78	0.09	2.81	0.15	26.2	0.59	568	7.2	31.65	0.63	3.03	0.52	-0.79	2.73
15	2.34	0.55	10.13	1.10	1.66	0.09	2.80	0.14	25.5	0.59	567	7.2	31.48	0.63	3.34	0.52	2.56	2.73
16	- -	- -	- -	- -	- -	- -	- -	- -	25.3	0.59	573	7.2	31.63	0.63	3.58	0.52	8.48	2.73
17	- -	- -	- -	- -	- -	- -	- -	- -	24.9	0.59	567	7.2	31.83	0.63	4.18	0.52	19.49	2.73
18	- -	- -	- -	- -	- -	- -	- -	- -	24.5	0.59	574	7.2	31.89	0.63	4.38	0.52	14.73	2.73
19	- -	- -	- -	- -	- -	- -	- -	- -	23.5	0.59	573	7.2	30.63	0.63	3.95	0.52	18.68	2.73
20	- -	- -	- -	- -	- -	- -	- -	- -	22.2	0.59	572	7.2	29.14	0.63	3.39	0.52	22.07	2.73
21	- -	- -	- -	- -	- -	- -	- -	- -	21.1	0.59	568	7.2	29.18	0.63	4.29	0.52	26.35	2.73
22	- -	- -	- -	- -	- -	- -	- -	- -	21.6	0.59	569	7.2	29.43	0.63	4.13	0.52	30.48	2.73
23	- -	- -	- -	- -	- -	- -	- -	- -	21.0	0.59	568	7.2	29.43	0.63	4.63	0.52	35.11	2.73
24	- -	- -	- -	- -	- -	- -	- -	- -	20.2	0.59	545	7.2	28.21	0.63	4.71	0.52	39.52	2.73
LSMEAN	2.65	0.14	8.29	0.28	1.67	0.02	2.57	0.04	25.3	0.12	567	1.5	29.64	0.13	1.66	0.11	2.59	0.56

Note: In tables 1-6, the units after T3 should be ng/ml.

TABLE 2

ENERGY BALANCE GROUP LESS THAN -50 MCAL CUMULATIVE ENERGY BALANCE - GRP 2

LEAST SQUARE MEANS

WK LAC	BGH (ng/ml)	SEM	INS (uU/ml)	SEM	T3 (uG/dl)	SEM	T4 (uG/dl)	SEM	FCM (kg)	SEM	WT (KG)	SEM	TDNRAT (Mcal)	SEM	EBAL (Mcal)	SEM	CUMEBAL (Mcal)	SEM
-4	4.35	0.57	10.26	1.38	1.86	0.09	3.78	0.18	- -- --		694	2.4	20.28	0.75	- -- --		- -- --	
-3	3.22	0.58	13.04	1.41	1.99	0.10	3.77	0.18	- -- --		704	2.4	19.79	0.77	- -- --		- -- --	
-2	1.85	0.58	9.39	1.41	2.07	0.10	3.65	0.19	- -- --		714	2.4	19.08	0.77	- -- --		- -- --	
-1	2.31	0.61	5.20	1.52	1.77	0.10	2.92	0.20	- -- --		719	2.5	15.50	0.80	- -- --		- -- --	
LSMEAN	2.94	0.29	9.47	0.71	1.92	0.05	3.53	0.09			708	1.2	18.68	0.39				

WK LAC	BGH (ng/ml)	SEM	INS (uU/ml)	SEM	T3 (uG/dl)	SEM	T4 (uG/dl)	SEM	FCM (kg)	SEM	WT (KG)	SEM	TDNRAT (Mcal)	SEM	EBAL (Mcal)	SEM	CUMEBAL (Mcal)	SEM
1	3.77	0.64	5.72	1.29	1.32	0.10	2.18	0.17	25.0	0.70	655	8.5	17.56	0.75	-11.32	0.61	-11.31	3.25
2	4.10	0.62	4.28	1.25	1.15	0.10	1.74	0.16	32.5	0.70	637	8.5	23.29	0.75	-10.91	0.61	-22.24	3.25
3	2.30	0.62	4.23	1.25	1.18	0.10	1.96	0.16	35.7	0.70	632	8.5	26.62	0.75	-9.88	0.61	-32.13	3.25
4	2.71	0.62	5.80	1.25	1.38	0.10	2.28	0.16	36.8	0.70	611	8.5	28.36	0.75	-8.67	0.61	-40.80	3.25
5	1.97	0.67	5.23	1.29	1.30	0.10	2.06	0.17	35.8	0.70	606	8.5	29.24	0.75	-7.00	0.61	-47.80	3.25
6	2.54	0.64	5.85	1.29	1.57	0.10	2.25	0.17	36.0	0.70	602	8.5	30.38	0.75	-5.97	0.61	-53.77	3.25
7	2.81	0.62	6.10	1.25	1.60	0.10	2.42	0.16	35.1	0.70	595	8.5	30.88	0.75	-4.68	0.61	-58.44	3.25
8	2.73	0.64	7.84	1.29	1.72	0.10	2.67	0.17	35.0	0.70	592	8.5	31.70	0.75	-3.76	0.61	-62.21	3.25
9	2.37	0.62	6.97	1.25	1.73	0.10	2.38	0.16	33.9	0.70	597	8.5	31.91	0.75	-2.77	0.61	-64.98	3.25
10	2.15	0.64	7.61	1.29	1.63	0.10	2.86	0.17	32.4	0.70	590	8.5	31.39	0.75	-2.11	0.61	-67.09	3.25
11	2.40	0.62	5.83	1.25	1.77	0.10	2.52	0.16	31.9	0.70	585	8.5	31.76	0.75	-1.36	0.61	-68.45	3.25
12	3.07	0.64	6.54	1.29	1.93	0.10	2.84	0.17	31.7	0.70	588	8.5	32.70	0.75	-0.31	0.61	-68.75	3.25
13	3.07	0.64	6.70	1.29	1.85	0.10	2.91	0.17	31.0	0.70	584	8.5	33.21	0.75	0.83	0.61	-67.92	3.25
14	2.61	0.64	7.21	1.29	1.83	0.10	2.93	0.17	30.3	0.70	586	8.5	32.92	0.75	1.01	0.61	-66.91	3.25
15	2.91	0.62	7.63	1.25	1.80	0.10	3.01	0.16	29.4	0.70	587	8.5	32.56	0.75	1.28	0.61	-65.64	3.25
16	- -	- -	- -	- -	- -	- -	- -	- -	29.1	0.70	589	8.5	32.39	0.75	1.32	0.61	-64.31	3.25
17	- -	- -	- -	- -	- -	- -	- -	- -	27.4	0.70	587	8.5	31.26	0.75	1.50	0.61	-62.84	3.25
18	- -	- -	- -	- -	- -	- -	- -	- -	28.2	0.70	590	8.5	31.87	0.75	1.43	0.61	-61.41	3.25
19	- -	- -	- -	- -	- -	- -	- -	- -	27.7	0.70	585	8.5	32.28	0.75	2.29	0.61	-59.12	3.25
20	- -	- -	- -	- -	- -	- -	- -	- -	27.7	0.70	586	8.5	32.17	0.75	2.16	0.61	-56.96	3.25
21	- -	- -	- -	- -	- -	- -	- -	- -	27.1	0.70	586	8.5	32.09	0.75	2.55	0.61	-54.42	3.25
22	- -	- -	- -	- -	- -	- -	- -	- -	26.4	0.70	591	8.5	31.52	0.75	2.43	0.61	-51.98	3.25
23	- -	- -	- -	- -	- -	- -	- -	- -	23.4	0.70	555	8.5	30.02	0.75	3.75	0.61	-45.09	3.25
24	- -	- -	- -	- -	- -	- -	- -	- -	23.2	0.70	555	8.5	29.96	0.75	3.82	0.61	-41.27	3.25
LSMEAN	2.77	0.16	6.24	0.33	1.58	0.03	2.47	0.04	30.5	0.14	595	1.7	30.34	0.15	-1.85	0.13	-53.99	0.66

P VALUES

DRY	BGH	INSULIN	T3	T4	FCM	WT	TDNRAT	EBAL	CUMEBAL
WEEK	0.0560	0.0003	0.1567	0.0001	- -	0.0001	0.0001	- -	- -
W*G	0.2090	0.1377	0.2146	0.3578	- -	0.6398	0.9715	- -	- -
GRP	0.0080	0.5131	0.4080	0.7826	- -	0.0063	0.1789	- -	- -
MODEL	0.1100	0.0001	0.0001	0.0001	- -	0.0001	0.0001	- -	- -
LACTATION									
WEEK	0.3314	0.0449	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
W*G	0.7907	0.8446	0.0359	0.0286	0.0004	0.0001	0.0644	0.0001	0.0001
GRP	0.6818	0.0008	0.2698	0.5420	0.0001	0.1172	0.4392	0.0001	0.0001
MODEL	0.0468	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

TABLE 3

PRODUCTION GROUP - LOW MILK - GROUP 1

LEAST SQUARE MEANS

WK LAC	BGH (ng/ml)	SEM	INS (uU/ml)	SEM	T3 (uG/dl)	SEM	T4 (uG/dl)	SEM	FCM (kg)	SEM	WT (KG)	SEM	TDNRAT (Mcal)	SEM	EBAL (Mcal)	SEM	CUMEBAL (Mcal)	SEM
-4	2.77	0.55	11.74	1.33	2.01	0.09	3.87	0.17	- --	--	623	2.3	17.82	0.70	- --	--	- --	--
-3	2.35	0.57	11.02	1.33	1.84	0.09	3.86	0.18	- --	--	632	2.2	17.73	0.70	- --	--	- --	--
-2	1.16	0.61	8.31	1.47	1.89	0.10	3.37	0.20	- --	--	639	2.2	17.21	0.70	- --	--	- --	--
-1	1.86	0.59	6.90	1.42	1.79	0.10	2.83	0.18	- --	--	649	2.2	14.76	0.70	- --	--	- --	--
LSMEAN	2.04	0.29	9.49	0.69	1.88	0.05	3.48	0.09			636	1.1	16.88	0.35				

WK LAC	BGH (ng/ml)	SEM	INS (uU/ml)	SEM	T3 (uG/dl)	SEM	T4 (uG/dl)	SEM	FCM (kg)	SEM	WT (KG)	SEM	TDNRAT (Mcal)	SEM	EBAL (Mcal)	SEM	CUMEBAL (Mcal)	SEM
1	2.66	0.59	10.31	1.18	1.64	0.10	2.40	0.15	18.6	0.63	590	7.8	17.60	0.68	-5.71	0.57	-5.71	3.16
2	3.41	0.59	7.52	1.14	1.30	0.09	2.11	0.15	24.6	0.63	572	7.8	22.89	0.68	-4.66	0.57	-10.37	3.16
3	2.76	0.56	6.93	1.12	1.51	0.09	2.40	0.14	26.7	0.63	562	7.8	25.31	0.68	-3.64	0.57	-14.01	3.16
4	3.00	0.59	6.19	1.18	1.51	0.10	2.29	0.15	27.6	0.63	557	7.8	27.36	0.68	-2.18	0.57	-16.19	3.16
5	2.51	0.58	8.84	1.15	1.80	0.09	2.86	0.15	27.8	0.63	557	7.8	28.21	0.68	-1.50	0.57	-17.68	3.16
6	2.80	0.61	6.70	1.18	1.65	0.10	2.49	0.15	27.5	0.63	554	7.8	29.12	0.68	-0.37	0.57	-18.06	3.16
7	2.44	0.56	7.11	1.12	1.76	0.09	2.83	0.14	27.2	0.63	556	7.8	29.48	0.68	0.25	0.57	-17.81	3.16
8	1.87	0.58	6.38	1.15	1.84	0.09	2.63	0.15	27.0	0.63	556	7.8	30.52	0.68	1.41	0.57	-16.40	3.16
9	2.17	0.56	8.51	1.12	1.82	0.09	3.08	0.14	26.3	0.63	561	7.8	30.22	0.68	1.57	0.57	-14.83	3.16
10	2.67	0.58	7.55	1.12	1.94	0.09	3.24	0.14	25.1	0.63	556	7.8	29.92	0.68	2.24	0.57	-12.59	3.16
11	2.49	0.58	7.58	1.14	1.9	0.09	2.96	0.15	24.7	0.63	555	7.8	29.88	0.68	2.48	0.57	-9.48	3.16
12	2.15	0.59	9.50	1.14	1.79	0.09	2.84	0.15	24.8	0.63	555	7.8	30.05	0.68	2.57	0.57	-7.60	3.16
13	3.29	0.56	7.65	1.12	1.75	0.09	2.91	0.14	24.4	0.63	554	7.8	30.60	0.68	3.39	0.57	-4.20	3.16
14	2.16	0.63	8.89	1.21	1.87	0.10	3.08	0.16	24.2	0.63	558	7.8	30.54	0.68	3.50	0.57	-0.71	3.16
15	2.37	0.58	9.38	1.14	1.69	0.09	2.92	0.15	24.1	0.63	558	7.8	30.37	0.68	3.39	0.57	2.68	3.16
16	- -	- -	- -	- -	- -	- -	- -	- -	23.8	0.63	566	7.8	30.51	0.68	3.64	0.57	6.32	3.16
17	- -	- -	- -	- -	- -	- -	- -	- -	23.6	0.63	563	7.8	30.61	0.68	3.99	0.57	20.76	3.16
18	- -	- -	- -	- -	- -	- -	- -	- -	23.4	0.63	569	7.8	30.48	0.68	3.86	0.57	14.15	3.16
19	- -	- -	- -	- -	- -	- -	- -	- -	22.5	0.63	567	7.8	29.64	0.68	3.79	0.57	17.94	3.16
20	- -	- -	- -	- -	- -	- -	- -	- -	20.7	0.63	564	7.8	27.90	0.68	3.34	0.57	21.28	3.16
21	- -	- -	- -	- -	- -	- -	- -	- -	19.9	0.63	559	7.8	28.40	0.68	4.56	0.57	25.84	3.16
22	- -	- -	- -	- -	- -	- -	- -	- -	20.5	0.63	562	7.8	28.41	0.68	4.07	0.57	29.91	3.16
23	- -	- -	- -	- -	- -	- -	- -	- -	19.8	0.63	562	7.8	28.77	0.68	4.95	0.57	34.87	3.16
24	- -	- -	- -	- -	- -	- -	- -	- -	19.3	0.63	538	7.8	27.72	0.68	4.98	0.57	39.50	3.16
LSMEAN	2.58	0.15	7.94	0.30	1.72	0.02	2.74	0.04	23.9	0.13	560	1.6	28.52	0.14	1.66	0.12	1.99	0.65

TABLE 4

PRODUCTION GROUP - HIGH MILK - GROUP 2

LEAST SQUARE MEANS

WK LAC	BGH (ng/ml)	SEM	INS (uU/ml)	SEM	T3 (uG/dl)	SEM	T4 (uG/dl)	SEM	FCM (kg)	SEM	WT (KG)	SEM	TDNRAT (Mcal)	SEM	EBAL (Mcal)	SEM	CUMEBAL (Mcal)	SEM
-4	3.12	0.56	12.12	0.14	1.82	0.09	3.91	0.17	- --	--	690	2.2	20.21	0.70	- --	--	- --	--
-3	2.78	0.55	13.44	1.33	1.91	0.09	3.74	0.17	- --	--	701	2.2	19.58	0.70	- --	--	- --	--
-2	2.01	0.55	9.43	1.33	1.93	0.09	3.56	0.17	- --	--	710	2.2	19.18	0.70	- --	--	- --	--
-1	2.15	0.57	7.59	1.42	1.66	0.10	2.66	0.19	- --	--	718	2.3	14.28	0.70	- --	--	- --	--
LSMEAN	2.52	0.28	10.64	0.67	1.83	0.05	3.47	0.09			705	1.1	18.31	0.35				

WK LAC	BGH (ng/ml)	SEM	INS (uU/ml)	SEM	T3 (uG/dl)	SEM	T4 (uG/dl)	SEM	FCM (kg)	SEM	WT (KG)	SEM	TDNRAT (Mcal)	SEM	EBAL (Mcal)	SEM	CUMEBAL (Mcal)	SEM
1	3.17	0.59	6.04	1.17	1.26	0.10	1.99	0.15	26.0	0.65	650	8.0	20.70	0.69	-8.80	0.58	-8.80	3.24
2	4.53	0.58	4.00	1.14	1.10	0.09	1.62	0.15	33.0	0.65	634	8.0	24.45	0.69	-10.10	0.58	-18.89	3.24
3	3.07	0.58	4.29	1.14	1.30	0.09	1.93	0.15	36.0	0.65	628	8.0	27.79	0.69	-8.90	0.58	-27.81	3.24
4	2.49	0.58	5.79	1.14	1.31	0.09	2.03	0.15	37.2	0.65	612	8.0	28.97	0.69	-8.36	0.58	-36.16	3.24
5	2.42	0.61	7.03	1.17	1.28	0.10	2.00	0.15	36.4	0.65	605	8.0	30.35	0.69	-6.31	0.58	-42.48	3.24
6	3.10	0.59	6.10	1.17	1.54	0.10	2.25	0.16	36.3	0.65	603	8.0	31.39	0.69	-5.19	0.58	-47.66	3.24
7	2.88	0.58	6.03	1.14	1.56	0.09	2.35	0.15	35.5	0.65	596	8.0	31.96	0.69	-3.95	0.58	-51.61	3.24
8	2.81	0.59	10.40	1.17	1.66	0.10	2.56	0.16	35.4	0.65	593	8.0	32.81	0.69	-2.98	0.58	-54.58	3.24
9	2.80	0.58	7.44	1.14	1.71	0.09	2.34	0.15	34.5	0.65	598	8.0	32.98	0.69	-2.18	0.58	-56.76	3.24
10	1.61	0.59	8.16	1.17	1.58	0.10	2.52	0.16	32.9	0.65	591	8.0	32.47	0.69	-1.41	0.58	-58.17	3.24
11	2.66	0.58	6.56	1.17	1.74	0.10	2.35	0.15	32.7	0.65	591	8.0	33.17	0.69	-0.57	0.58	-58.74	3.24
12	2.78	0.59	7.17	1.17	1.83	0.10	2.65	0.16	32.8	0.65	592	8.0	33.78	0.69	-0.05	0.58	-58.79	3.24
13	2.85	0.59	7.09	1.17	1.76	0.10	2.63	0.15	32.1	0.65	595	8.0	34.27	0.69	0.89	0.58	-57.90	3.24
14	2.43	0.59	8.90	1.17	1.73	0.10	2.64	0.16	31.8	0.65	593	8.0	33.91	0.69	0.82	0.58	-57.08	3.24
15	2.81	0.59	8.76	1.17	1.75	0.10	2.88	0.15	30.3	0.65	593	8.0	33.57	0.69	1.55	0.58	-55.54	3.24
16	- -	- -	- -	- -	- -	- -	- -	- -	30.1	0.65	595	8.0	33.45	0.69	1.60	0.58	-51.13	3.24
17	- -	- -	- -	- -	- -	- -	- -	- -	28.4	0.65	588	8.0	32.63	0.69	2.10	0.58	-51.83	3.24
18	- -	- -	- -	- -	- -	- -	- -	- -	28.8	0.65	594	8.0	33.35	0.69	2.42	0.58	-49.37	3.24
19	- -	- -	- -	- -	- -	- -	- -	- -	28.1	0.65	589	8.0	33.07	0.69	2.7	0.58	-46.68	3.24
20	- -	- -	- -	- -	- -	- -	- -	- -	28.5	0.65	592	8.0	33.02	0.69	2.39	0.58	-44.29	3.24
21	- -	- -	- -	- -	- -	- -	- -	- -	27.5	0.65	593	8.0	32.47	0.69	2.52	0.58	-41.77	3.24
22	- -	- -	- -	- -	- -	- -	- -	- -	26.9	0.65	595	8.0	32.28	0.69	2.75	0.58	-39.02	3.24
23	- -	- -	- -	- -	- -	- -	- -	- -	24.3	0.65	564	8.0	30.64	0.69	3.54	0.58	-32.81	3.24
24	- -	- -	- -	- -	- -	- -	- -	- -	23.6	0.65	561	8.0	30.21	0.69	3.67	0.58	-29.13	3.24
LSMEAN	2.83	0.15	6.92	0.3	1.54	0.02	2.32	0.04	31.2	0.13	598	1.6	31.40	0.14	-1.33	0.12	-44.87	0.66

P VALUES

DRY	BGH	INSULIN	T3	T4	FCM	WT	TDNRAT	EBAL	CUMEBAL
WEEK	0.0882	0.0007	0.1723	0.0001	- -	0.0001	0.0001	- -	- -
W*G	0.9630	0.8797	0.3890	0.7298	- -	0.7811	0.1740	- -	- -
GRP	0.2792	0.4452	0.7126	0.9654	- -	0.0034	0.2994	- -	- -
MODEL	0.2226	0.0001	0.0001	0.0001	- -	0.0001	0.0001	- -	- -
LACTATION									
WEEK	0.3273	0.0222	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
W*G	0.9425	0.1602	0.1518	0.2048	0.0001	0.0240	0.7755	0.0001	0.0001
GRP	0.3705	0.1107	0.0124	0.0097	0.0001	0.0268	0.0005	0.0001	0.0001
MODEL	0.0718	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

TABLE 5

DRY COW TREATMENT GROUP - 110% NRC - GROUP 1

LEAST SQUARE MEANS

WK LAC	BGH (ng/ml)	SEM	INS (uU/ml)	SEM	T3 (uG/dl)	SEM	T4 (uG/dl)	SEM	FCM (kg)	SEM	WT (KG)	SEM	TDNRAT (Mcal)	SEM	EBAL (Mcal)	SEM	CUMEBAL (Mcal)	SEM
-4	2.86	0.56	8.92	1.31	1.72	0.09	3.48	0.17	--	--	642	2.3	14.87	0.66	--	--	--	--
-3	1.99	0.57	9.90	1.29	1.68	0.09	3.45	0.18	--	--	654	2.2	14.85	0.67	--	--	--	--
-2	1.21	0.57	7.44	1.34	1.69	0.09	2.98	0.18	--	--	656	2.2	14.80	0.67	--	--	--	--
-1	1.40	0.61	7.43	1.38	1.48	0.10	2.27	0.18	--	--	667	2.2	12.74	0.70	--	--	--	--
LSMEAN	1.86	0.29	8.42	0.66	1.64	0.05	3.05	0.09			655	1.1	14.31	0.34				

WK LAC	BGH (ng/ml)	SEM	INS (uU/ml)	SEM	T3 (uG/dl)	SEM	T4 (uG/dl)	SEM	FCM (kg)	SEM	WT (KG)	SEM	TDNRAT (Mcal)	SEM	EBAL (Mcal)	SEM	CUMEBAL (Mcal)	SEM
1	2.39	0.59	8.56	1.18	1.30	0.10	1.90	0.15	22.5	0.67	609	7.9	20.08	0.69	-6.32	0.60	-6.32	3.97
2	4.55	0.59	6.21	1.15	1.12	0.09	1.71	0.15	29.2	0.67	595	7.9	24.37	0.69	-6.88	0.60	-13.20	3.97
3	2.98	0.57	5.96	1.15	1.44	0.09	2.02	0.15	31.5	0.67	583	7.9	27.08	0.69	-5.70	0.60	-18.90	3.97
4	2.86	0.59	5.62	1.18	1.30	0.10	2.03	0.15	32.4	0.67	575	7.9	28.52	0.69	-4.81	0.60	-23.71	3.97
5	2.69	0.59	9.53	1.18	1.51	0.10	2.35	0.15	32.1	0.67	572	7.9	29.70	0.69	-3.38	0.60	-27.09	3.97
6	2.94	0.64	6.38	1.25	1.61	0.10	2.28	0.16	31.7	0.67	571	7.9	30.72	0.69	-2.08	0.60	-29.17	3.97
7	2.86	0.57	5.42	1.15	1.47	0.09	2.40	0.15	31.5	0.67	567	7.9	31.02	0.69	-1.53	0.60	-30.70	3.97
8	3.34	0.59	7.98	1.15	1.66	0.09	2.47	0.15	31.0	0.67	568	7.9	31.95	0.69	-0.27	0.60	-30.98	3.97
9	2.19	0.57	7.79	1.15	1.75	0.09	2.51	0.15	30.4	0.67	572	7.9	31.92	0.69	0.10	0.60	-30.88	3.97
10	2.69	0.61	8.23	1.18	1.71	0.10	2.60	0.15	29.4	0.67	567	7.9	31.60	0.69	0.62	0.60	-30.26	3.97
11	2.87	0.57	7.58	1.18	1.74	0.10	2.62	0.15	28.5	0.67	567	7.9	31.65	0.69	1.33	0.60	-28.93	3.97
12	2.03	0.62	9.34	1.21	1.79	0.10	2.71	0.16	28.6	0.67	565	7.9	32.04	0.69	1.63	0.60	-27.30	3.97
13	2.62	0.59	9.31	1.18	1.69	0.10	2.64	0.15	27.9	0.67	569	7.9	32.70	0.69	2.72	0.60	-24.58	3.97
14	2.19	0.64	10.85	1.25	1.85	0.10	3.05	0.16	27.9	0.67	567	7.9	32.26	0.69	2.39	0.60	-22.19	3.97
15	2.46	0.60	9.47	1.21	1.86	0.10	2.83	0.16	27.3	0.67	568	7.9	31.94	0.69	2.43	0.60	-19.76	3.97
16	--	--	--	--	--	--	--	--	27.1	0.67	571	7.9	32.40	0.69	3.06	0.60	-13.89	3.97
17	--	--	--	--	--	--	--	--	26.3	0.67	565	7.9	32.14	0.69	3.43	0.60	-13.27	3.97
18	--	--	--	--	--	--	--	--	26.2	0.67	573	7.9	32.42	0.69	3.72	0.60	-9.55	3.97
19	--	--	--	--	--	--	--	--	24.8	0.67	572	7.9	31.46	0.69	3.82	0.60	-5.73	3.97
20	--	--	--	--	--	--	--	--	24.2	0.67	573	7.9	31.05	0.69	3.78	0.60	-1.94	3.97
21	--	--	--	--	--	--	--	--	23.9	0.67	573	7.9	31.52	0.69	4.47	0.60	2.53	3.97
22	--	--	--	--	--	--	--	--	23.9	0.67	576	7.9	31.06	0.69	3.98	0.60	6.51	3.97
23	--	--	--	--	--	--	--	--	23.6	0.67	573	7.9	31.15	0.69	4.37	0.60	10.88	3.97
24	--	--	--	--	--	--	--	--	22.4	0.67	574	7.9	30.57	0.69	4.62	0.60	15.5	3.97
LSMEAN	2.78	0.15	7.88	0.31	1.59	0.03	2.41	0.04	27.7	0.14	574	1.6	30.47	0.14	0.65	0.12	-15.54	0.81

TABLE 6

DRY COW TREATMENT GROUP - 160% NRC - GROUP 2

LEAST SQUARE MEANS

WK LAC	BGH (ng/ml)	SEM	INS (uU/ml)	SEM	T3 (uG/dl)	SEM	T4 (uG/dl)	SEM	FCM (kg)	SEM	WT (KG)	SEM	TDNRAT (Mcal)	SEM	EBAL (Mcal)	SEM	CUMEBAL (Mcal)	SEM
-4	3.05	0.55	14.86	1.29	2.11	0.09	4.29	0.17	- -- --		671	2.2	23.19	0.67	- -- --		- -- --	
-3	3.12	0.55	14.56	1.29	2.07	0.09	4.15	0.17	- -- --		679	2.2	22.46	0.67	- -- --		- -- --	
-2	2.01	0.59	10.28	1.39	2.14	0.10	3.98	0.19	- -- --		693	2.2	21.58	0.67	- -- --		- -- --	
-1	2.56	0.55	7.07	1.39	1.97	0.10	3.23	0.19	- -- --		699	2.2	16.47	0.67	- -- --		- -- --	
LSMEAN	2.68	0.28	11.69	0.67	2.07	0.05	3.91	0.09			686	1.1	20.92	0.34				

WK LAC	BGH (ng/ml)	SEM	INS (uU/ml)	SEM	T3 (uG/dl)	SEM	T4 (uG/dl)	SEM	FCM (kg)	SEM	WT (KG)	SEM	TDNRAT (Mcal)	SEM	EBAL (Mcal)	SEM	CUMEBAL (Mcal)	SEM
1	3.44	0.59	7.82	1.18	1.60	0.10	2.50	0.15	21.9	0.65	629	7.8	18.19	0.68	-8.07	0.60	-8.07	3.89
2	3.45	0.57	5.36	1.15	1.28	0.09	2.03	0.15	28.3	0.65	610	7.8	22.97	0.68	-7.72	0.60	-15.79	3.89
3	2.84	0.56	5.35	1.12	1.37	0.09	2.31	0.15	31.0	0.65	605	7.8	25.99	0.68	-6.69	0.60	-22.49	3.89
4	2.60	0.57	6.38	1.15	1.52	0.09	2.29	0.15	32.1	0.65	592	7.8	27.79	0.68	-5.55	0.60	-28.05	3.89
5	2.24	0.59	6.45	1.15	1.58	0.09	2.53	0.15	31.9	0.65	589	7.8	28.83	0.68	-4.30	0.60	-32.34	3.89
6	2.94	0.56	6.37	1.12	1.59	0.09	2.46	0.15	31.9	0.65	584	7.8	29.76	0.68	-3.33	0.60	-35.66	3.89
7	2.45	0.56	7.69	1.12	1.84	0.09	2.79	0.15	31.1	0.65	583	7.8	30.37	0.68	-2.05	0.60	-37.72	3.89
8	1.37	0.57	8.76	1.18	1.84	0.10	2.70	0.16	31.2	0.65	581	7.8	31.34	0.68	-1.16	0.60	-38.88	3.89
9	2.75	0.56	8.17	1.12	1.79	0.09	2.91	0.15	30.2	0.65	586	7.8	31.23	0.68	-0.60	0.60	-39.47	3.89
10	1.69	0.56	7.44	1.12	1.82	0.09	3.17	0.15	28.4	0.65	579	7.8	30.75	0.68	0.30	0.60	-39.17	3.89
11	2.28	0.57	6.61	1.15	1.90	0.09	2.70	0.15	28.7	0.65	577	7.8	31.32	0.68	0.68	0.60	-37.87	3.89
12	2.82	0.56	7.50	1.12	1.83	0.09	2.78	0.15	28.8	0.65	581	7.8	31.71	0.68	0.97	0.60	-37.59	3.89
13	3.49	0.56	5.61	1.12	1.82	0.09	2.89	0.15	28.4	0.65	579	7.8	32.10	0.68	1.65	0.60	-35.94	3.89
14	2.37	0.57	7.27	1.15	1.77	0.09	2.71	0.15	27.9	0.65	583	7.8	32.10	0.68	2.01	0.60	-33.93	3.89
15	2.68	0.56	8.71	1.12	1.61	0.09	2.96	0.15	26.9	0.65	582	7.8	31.92	0.68	2.54	0.60	-31.39	3.89
16	- -	- -	- -	- -	- -	- -	- -	- -	26.7	0.65	588	7.8	31.51	0.68	2.25	0.60	-29.14	3.89
17	- -	- -	- -	- -	- -	- -	- -	- -	25.5	0.65	586	7.8	31.08	0.68	2.72	0.60	-15.96	3.89
18	- -	- -	- -	- -	- -	- -	- -	- -	25.9	0.65	589	7.8	31.37	0.68	2.62	0.60	-23.78	3.89
19	- -	- -	- -	- -	- -	- -	- -	- -	25.7	0.65	583	7.8	31.17	0.68	2.72	0.60	-21.06	3.89
20	- -	- -	- -	- -	- -	- -	- -	- -	24.8	0.65	582	7.8	29.78	0.68	2.01	0.60	-19.05	3.89
21	- -	- -	- -	- -	- -	- -	- -	- -	23.3	0.65	578	7.8	29.31	0.68	2.71	0.60	-16.34	3.89
22	- -	- -	- -	- -	- -	- -	- -	- -	23.3	0.65	580	7.8	29.57	0.68	2.89	0.60	-13.45	3.89
23	- -	- -	- -	- -	- -	- -	- -	- -	20.5	0.65	553	7.8	28.28	0.68	4.16	0.60	-6.74	3.89
24	- -	- -	- -	- -	- -	- -	- -	- -	20.4	0.65	526	7.8	27.38	0.68	4.07	0.60	-3.01	3.89
LSMEAN	2.63	0.15	7.03	0.29	1.68	0.02	2.65	0.04	27.3	0.13	584	1.6	29.41	0.14	-0.22	0.12	-25.95	0.79

P VALUES

DRY	BGH	INSULIN	T3	T4	FCM	WT	TDNRAT	EBAL	CUMEBAL
WEEK	0.0879	0.0005	0.1659	0.0001	- -	0.0001	0.0001	- -	- -
W*G	0.8073	0.1133	0.9349	0.8306	- -	0.1111	0.0059	- -	- -
GRP	0.0611	0.0251	0.0005	0.0032	- -	0.2118	0.0001	- -	- -
MODEL	0.2002	0.0001	0.0001	0.0001	- -	0.0001	0.0001	- -	- -
LACTATION									
WEEK	0.3042	0.0195	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
W*G	0.4553	0.4180	0.1696	0.3997	0.7308	0.0133	0.8695	0.9993	0.4126
GRP	0.5850	0.1871	0.2177	0.1507	0.7708	0.5646	0.2333	0.2238	0.3414
MODEL	0.0228	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

D. COOPERATION

The cooperation in obtaining the blood samples and performance information in BARD Project I-106-79 represented extensive planning and several visits to the U.S.A. and one to Israel by the various collaborators. These visits were working sessions to examine the data, edit it continuously and work out a method for determining the energy balance.

During several of these visits possible hormonal analysis of blood samples being collected, but for which no money was budgeted for analysis, was discussed. A proposal to analyze these samples and relate them to all the performance data which was available at no additional cost was rejected by BARD, unfortunately. A simpler proposal to examine only a few cows (40) was submitted to BARD. This proposal for one year has resulted in the attached report.

Dr. Shaul Eger visited the U.S.A. to assist in the preparation of the report at his expense. The Cornell P.I. (RHF) paid for all living costs for Dr. Eger while in the U.S.A. from non-BARD funds. Dr. T. R. Rounsaville and Dr. Jim Ferguson at Cornell contributed extensively to the analysis and interpretation of the results, all without funding from BARD. This represents a major cooperative effort, initiated in the original project and continuing in the present project, with at least half of the cost of the present project borne by sources outside of BARD.

E. RESEARCH ACHIEVEMENTS

This project took advantage of blood samples that had already been collected in an earlier project. This earlier project contained extensive individual cow information on reproduction, production and energy relationships. New funds were only available to analyze blood on a limited number of cows. Previous requests to analyze a larger number of samples had been denied, so with the passage of time assays were limited to hormones which were expected to be relatively stabile in samples stored frozen for a considerable length of time.

Significant relationships were established between various blood hormone concentrations with differences between cows grouped on the basis of milk production and also by cumulative net energy balance. Of special interest in the latter group was the consistent difference from parturition onward in blood insulin concentrations. By taking blood samples early in the postpartum period hormone analyses should help to identify those cows requiring special management to achieve optimal production and reproduction.

Several other hormonal combinations, in preliminary analyses, suggest that these data can be used in detailed modeling studies to design new experiments which will focus on obtaining the important measurements at critical times early in the postpartum period. This will provide additional information so that nutritional management can be provided to optimize production and reproduction for each cow or group of cows. With the development of rapid assays, electronic mail and computer systems, dairy cow management teams can quickly implement feeding strategies to minimize the problems which would otherwise occur when cows with high production potential are in a negative energy balance for long periods.

F. PUBLICATIONS

No publications are published yet on this short project. However, there are several publications from the original project, including a major overall publication though SEARCH at Cornell, which has been written. The detailed blood work in relation to energy balance and reproduction reported in this report is being prepared in abbreviated form for publication.