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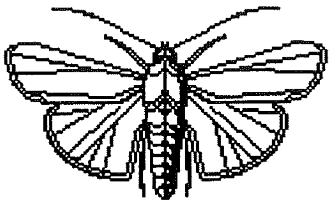

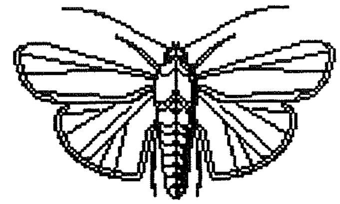

RESPONSE OF THE FRUITTREE LEAFROLLER (*ARCHIPS ARGYROSPILA*) TO SALT TOLERANT, BALDCYPRESS (*TAXODIUM DISTICHUM*) SEEDLINGS

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Abstract

The coastal forests of the United States are being destroyed by many different agents. Two of these agents are saltwater intrusion and fruittree leafroller (FTLR) (*Archips argyrospila*) defoliation. Restoration efforts have begun, but are not likely to succeed without a concerted effort to find varieties of baldcypress that are resistant to salinity while also being less prone to FTLR attack. It has already been established that different families of baldcypress vary in their responses to increasing salinity levels. This experiment serves to shed some light on the problem of the FTLR and its relationship to families of baldcypress being considered for restoration projects, based on their tolerance to salinity.

FTLR's were reared on six families varying in salt tolerance. Total survival of the larvae on each family, development time, and pupal weight were analyzed using SAS. A significant difference was detected between the families in regard to development time. The males of the salt-tolerant family CB-3 developed faster than did the males reared on all other families except FA-2, the other salt-tolerant family. No other variables were statistically significant, though there appeared to be a hint of a trend that may, with further research, lead to an indication that larvae may, in some ways, perform better on salt-tolerant species and worse on salt-intolerant species.

Introduction

Baldcypress

Baldcypress (*Taxodium distichum*), though it's habitat is widespread, has become a symbol of Louisiana's forested wetlands and is indeed one of Louisiana's valuable natural resources. The strong, durable wood of old growth cypress has given it a high commercial value. The value of Louisiana's cypress trees comes not only in commercial value, but in ecological value. Baldcypress plays an important role in the wetland ecosystem of South Louisiana by performing functions such as reducing soil erosion, providing wildlife habitat, and by providing habitat for a large number of other organisms that comprise the biodiversity of forested wetlands.

The baldcypress trees of Louisiana's forested wetlands are facing danger from two separate avenues. The first is that of saltwater intrusion, and the second is defoliation by the fruittree leafroller (*Archips argyrospila*). Many of the currently established trees of the forested wetlands are not able to adapt to increasing salinity levels. When combined with flooding, abnormally high salinity levels result in damage to cypress, causing substantial reductions in carbon assimilation. This condition can lead to additional problems, including weaker seedlings and decreased seedling survival rates (Pezeshki et. al., 1990). Eventually, with increasing concentrations of salinity, baldcypress trees die, leaving an ecological void in the plant community structure and composition.

Restoration Efforts

Due to rapid subsidence, global changes in sea-level, and various human alterations to the environment, such as canals and levees, water-levels and salinity levels are increasing. This flooding, combined with the increased salinity levels causes a substantial reduction in net photosynthesis in many of the swamp-forest tree species growing along the United States' Gulf Coast. This flooding and saltwater intrusion is causing the deterioration and loss of the coastal forests of the United States. Even baldcypress and blackgum (*Nyssa aquatica*), two of the most flood-tolerant species of the Gulf Coastal region, are salt sensitive (Pezeshki et al, 1990).

With the growing concern for loss of coastline, saltwater intrusion, and loss of coastal forests, swampland restoration efforts are being put into practice. Interest is rising in planting baldcypress seedlings in an attempt to restore some of the coastal forests that are so rapidly deteriorating. However, the flooding and saltwater intrusion remain a problem. There is a need for seedlings that will be able to survive in the new, harsher environment. Therefore, salt-tolerant species of baldcypress are sought after in restoration efforts, and research is being conducted in this area.

Flooding and saltwater intrusion are not the only problems plaguing baldcypress in Louisiana's swampland. An insect defoliator called the fruittree leafroller is also becoming a serious problem. It defoliates thousands of acres of baldcypress per year (Meeker, 1993). While the initial defoliation does not kill the

tree, it slows down its growth. However, repeated defoliation will kill a tree. Younger trees are more susceptible to the detrimental effects of defoliation than are older trees (Goyer, personal communication).

The fruittree leafroller, combined with saltwater intrusion, poses a challenge to swampland restoration efforts. Restoration efforts may hinge on finding a variety/family of baldcypress that is as tolerant to salt water as possible, and also hinders the growth and reproduction of fruittree leafrollers. No good is accomplished if a salt tolerant seedling is planted and then repeatedly defoliated until its demise.

The Fruittree Leafroller

The fruittree leafroller (FTLR) belongs to the genus *Archips*, of which there are 21 species in North America and northern Mexico. It is a small moth with a wingspan of approximately 14 to 23 mm. The color of the front wings ranges from dark brown to light rust; each wing sports two noticeable whitish patches. The hind wings are of a grayish-blue color (Meeker, 1992).

The FTLR is native to the United States, where it feeds on most plants. In fact, significantly detrimental numbers occur on species such as apple (*Malus* spp.), apricot (*Prunus armeniaca* L.), peach (*Prunus persica* (L.) Batsch), and plum (*Prunus* spp.). The FTLR has also been noted feeding on such trees as maple (*Acer* spp.)

hickory (*Carya* spp.) and oak (*Quercus* spp.) (Gill, 1913). In the Louisiana swampland, the FTLR feeds on baldcypress. This population may be a unique ecotype of the species, especially considering that previously noted FTLR feeding on conifers has been minimal (Goyer, et al, 1995).

The FTLR is univoltine, meaning that only one generation is produced per year. In Louisiana, eggs begin to hatch close to the time of bud break, which is usually in late February or early March. The first instar larvae make their way to the young needles and use their silk to roll the needles tightly around themselves. They feed inside these self-made cavities (Braun et al, 1990).

The FTLR passes through 5 instars before pupating. The first instar larvae measures only several millimeters, while the fifth instar larvae may grow up to 2 cm in length. FTLR's pupate for approximately 8 to 12 days before emerging. Adult FTLR's emerge from late April to mid-May in Louisiana. Adults usually only live for 14 days. They lay egg masses, containing approximately 54 eggs, on the underside of twigs 2 to 3 days after mating. The egg masses then remain dormant until the following spring (Braun et al, 1990).

The fruittree leafroller has been a serious pest of fruit trees throughout the United States for decades (Gill, 1913). However, it is a relatively new problem to Louisiana's baldcypress. The first report of FTLR feeding on baldcypress came in 1983, and since then, defoliation of baldcypress by the FTLR has increased in

geographic scale. In southern Louisiana, as many as 200,000 acres of baldcypress have been defoliated by the leafroller in a single season (Meeker and Goyer, 1993).

Repeated defoliation appears to have a more damaging effect on younger trees. Present research underway at the Louisiana Agricultural Experiment Station is directed towards determining the reason this occurs (Goyer, personal communication). Though the leafroller goes through only one generation per year, it is seriously destructive, and defoliation and subsequent impact of growth and survival may prove to be a great hindrance to reforestation efforts in forested wetlands.

Previous Work and Present Outlook

Previous experiments have been conducted in the areas of cypress response to salinity and the effects of the FTLR on baldcypress in Louisiana (Allen and Chambers, 1994; Allen, Chambers, and McKinney, 1994). However, no studies have been conducted which link these two problem areas.

In a study conducted by Allen and Chambers (1994), 15 different families of baldcypress, 10 from brackish, coastal waters, and 5 from freshwater sources, were subjected to flooding with various concentrations of saline water. They found that the families of seedlings from the brackish sources exposed to the salt water were generally more tolerant to the saline solution than were the freshwater families. The brackish families also retained more leaves and attained a larger mean leaf size.

Two studies conducted by Meeker and Goyer (1993, 1994) indicated that the FTLR prefers cypress with open foliage to those with appressed foliage. Though the 1993 study concluded that there were no ovipositional differences between the two morphology types, there was a difference in defoliation level. Therefore, the differences in level of defoliation were attributed to the type of morphology best suited to the development of the larvae.

This project is focused primarily on determining if several previously screened breeding lines (families) of baldcypress, differing in salt tolerance, are likely to be differentially susceptible to fruittree leafroller defoliation. This will be accomplished by evaluating the foliage of each family to ascertain its effect on fruittree leafroller caterpillar survival, development rates, and subsequent pupal weight.

Materials and Methods

Baldcypress seedlings of six of the families studied by Allen and Chambers, were used for this experiment. These families are from areas varying in salinity levels. These six different families are as follows: SG2, from St. Gore (in St. Bernard Parish, LA); VE2, from Venice, LA; FA2, from Falgout Canal (south of Houma, LA); CB3, from Mobile Bay, AL, and SW1 and SW2 from Sherburne Wildlife Management area (in the Atchafalaya Basin, near Whiskey Bay) (Fig. 1). According to Allen and Chambers (1995), families SW-1 and SW-2 were salt

intolerant, SG-2 and VE-2 were moderately tolerant, and CB-3 and FA-2 were somewhat tolerant of salinity levels of up to 8 ppm.

Third instar FTLR larvae were collected on April 17, 1996. Leaves were clipped from cypress seedlings grown by Mr. Ken Krauss, a graduate student in Tree Physiology. Approximately 100 leaves were clipped from each family. The leaves

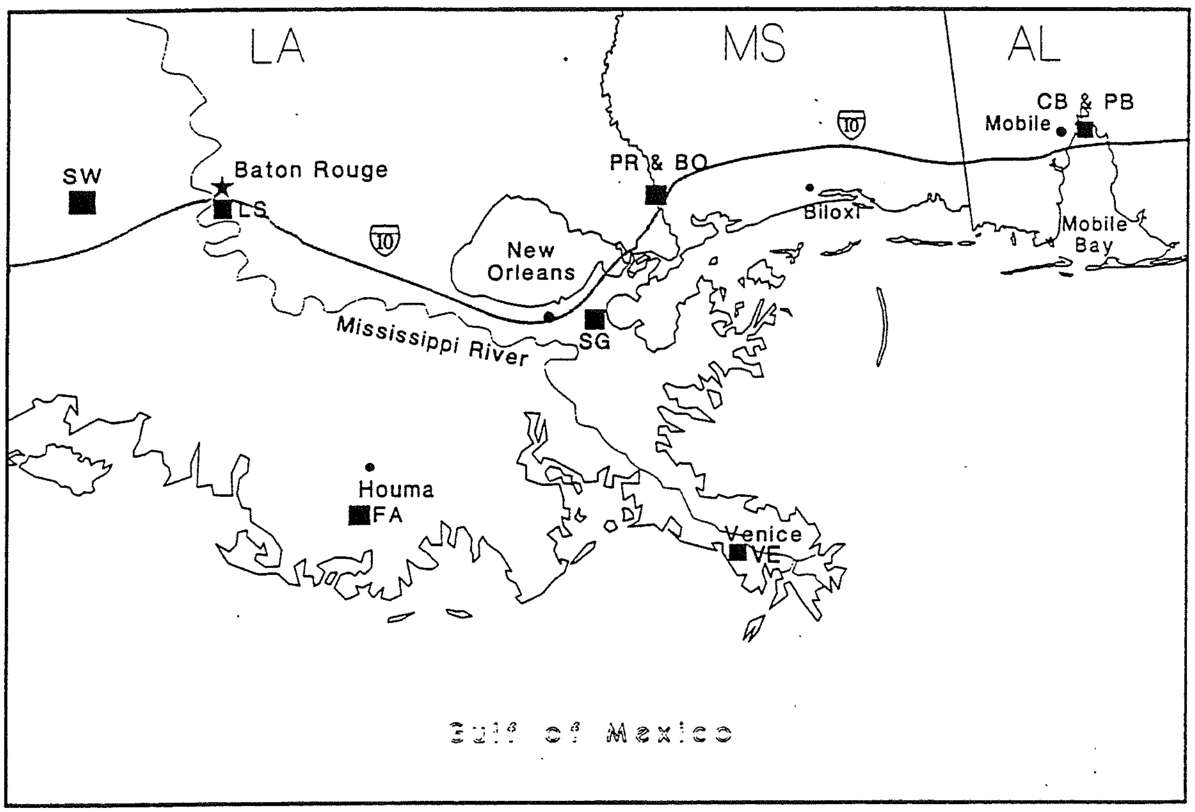

Fig. 1. Approximate locations of trees used as seed sources. The letters by each shaded area indicate which family(ies) were obtained there.

(Allen and Chambers, 1995)

were then taken to the lab where 10 were randomly picked to be measured in length and width. The fruittree leafroller larvae were placed in plastic petri dishes. There were ten dishes (reps) per family, with five larvae per rep. If at all possible, larvae of the same instar were placed in the same dish, to facilitate the transfer of pupae later in the experiment.

The dishes were changed every Monday, Wednesday, and Friday. This consisted of collecting the leaves at the greenhouse, measuring a sample of ten leaves per family, filling clean dishes with fresh leaves, and transferring surviving larvae from the old to the new dish. During the changing, the instar of each larvae in the rep was noted, as well as its health. Dead larvae were tallied for each rep. Diseased larvae were noted, but left in their respective dishes, pending mortality. The presence of pupae was noted. After pupation, the pupae were removed from the petri dishes containing foliage, so that they could be weighed. Each pupa was weighed and labeled by treatment (family/rep).

SAS was used to run the statistical analyses. The analyses were run on survival, development time/rate of development, and pupal weights by the family on which the larvae were reared in order to determine if certain families provided a better nutritive source and, thus, might be more (or less) susceptible to caterpillar deprivation in the field.

RESULTS

Three general areas were looked at statistically. These areas were survival, development time, and pupal weight. A Chi-square test was run on the survival data because the survival data were not taken by rep, the total survival, per treatment, was used. Analysis of variance (ANOVA) tests were run on the development time and pupal weight, to determine if a significant difference between families exists. The data were roughly divided, by weight, into male and female subsets before the tests were run.

Survival

The data obtained from the Chi-square analysis can be found in Table 1.

Table 1. Percent Survival by Family.

Family	# live	# dead	% mean survival
SW-1	20	18	52.63
SW-2	30	10	75.00
SG-2	25	10	71.43
VE-2	25	8	75.76
CB-3	29	9	76.32
FA-2	31	8	79.49
Totals	160	63	65.44 (mean survival, overall)

The mean survival rates ranged from 52.63 to 79.49 percent, but none of these differences was found to be significant at $p > .1$. However, the data did seem to follow a general trend, moving from lower survival on the least tolerant species, to better survival on the most tolerant species. There is reason to believe that a significant difference could be detected, should survival have been tested within the different reps.

Before running the ANOVA tests by sex on development time and pupal weight, the data were tested to see if they were normally distributed. When the data were found to be normally distributed, the ANOVA was completed.

The only significant differences found in the development time occurred in males. The mean development time for family CB-3 was significantly lower than families SW-1, SW-2, VE-2, and SG-2, but not significantly different from FA-2. FA-2 was not significantly different from any of the families. However, these data do seem to show a possible trend that could be examined in further research. Some semblance of an inverse relationship may exist because development time seems to tend to decrease as salt tolerance increases.

Table 2. SAS ANOVA Output Describing the Development Time in Male FTLR's in days

```
------------------------------------ SEX=M ------------------------------------

                     General Linear Models Procedure

      Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: DTIME

       NOTE: This test controls the type I experimentwise error rate.

                  Alpha= 0.05  df= 93  MSE= 7.669014
                  WARNING: Cell sizes are not equal.
                Harmonic Mean of cell sizes= 16.03882

   Number of Means           2         3         4         5         6
   Critical F        5.9121887 3.8253563 3.0217167 2.4695953 2.3123385

       Means with the same letter are not significantly different.

          REGWF Grouping             Mean       N  FAMILY

                      A            17.118      17  SW-2
                      A
                      A            16.462      13  SW-1
                      A
                      A            16.267      15  VE-2
                      A
                      A            16.105      19  SG-2
                      A
              B       A            14.571      21  FA-2
              B
              B                    13.214      14  CB-3
```

There were no significant differences in the development time of female FTLR's. However, the same inverse relationship of salt tolerance to development time, though statistically insignificant, exists in the data for the females.

Table 3. SAS ANOVA Output Describing the Development Time in Female FTLR's in days

```
------------------------------------ SEX=F ------------------------------------

                    General Linear Models Procedure

     Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: DTIME

      NOTE: This test controls the type I experimentwise error rate.

                  Alpha= 0.05  df= 39  MSE= 7.89782
                  WARNING: Cell sizes are not equal.
                Harmonic Mean of cell sizes= 3.795094

Number of Means         2          3          4         5         6
Critical F      6.2232336  4.045492  3.202779 2.6123056 2.4558306

      Means with the same letter are not significantly different.

          REGWF Grouping          Mean       N  FAMILY

                       A        19.000       1  SW-1
                       A
                       A        18.545      11  SW-2
                       A
                       A        17.875       8  SG-2
                       A
                       A        17.333       9  FA-2
                       A
                       A        17.222       9  VE-2
                       A
                       A        16.857       7  CB-3
```

Pupal weight, a measure of overall fitness, was also tested for significant differences between families. The means found for each family are presented in Table 4.

Table 4. Pupal Weights of FTLR Reared on Six Baldcypress Families Exhibiting Varying Tolerance to Salinity.

Family	Sex	Mean Pupal Wt. (g)
SW-1	M	0.032
SW-1	F	0.053
SW-2	M	0.031
SW-2	F	0.046
SG-2	M	0.029
SG-2	F	0.049
VE-2	M	0.032
VE-2	F	0.051
CB-3	M	0.028
CB-3	F	0.046
FA-2	M	0.031
FA-2	F	0.049

All means found to be not significant at P = 0.05 by ANOVA

No significant differences in pupal weight were found between families in either the male or female tests. Though lower pupal weights for both males and females were found in the salt-tolerant family CB-3, the families did not show any particular trends linking pupal weight to salt tolerance in either the male or female tests.

Leaf measurements were taken as a point of interest, due to the fact that studies have shown that leaf morphology has an effect on FTLR host-tree preference. The average leaf measurements are presented in Table 5. Leaf length was measured from where the leaf joins the twig to the tip of the leaf, and leaf width was measured at the widest point of the leaf.

Table 5. Average Leaf Measurements of Baldcypress Leaves Fed to Growing FTLR Larvae, by Family.

Family	Avg. Leaf Length (cm)	Avg. Leaf Width (cm)
SW-1	5.83	1.99
SW-2	6.39	2.06
SG-2	6.63	2.06
VE-2	6.47	2.05
CB-3	5.88	2.14
FA-2	5.74	1.85

Discussion

Though there were few statistically significant results, it is still possible to glean information from this study that may, with further research, prove useful in the coastal forest restoration efforts. Each of the areas tested has the potential to affect the severity of FTLR outbreaks in baldcypress stands.

Survival is an important variable because the more FTLR's that survive, the more that will be left to defoliate and reproduce. Though there were no significant differences found between families in relation to total survival per family, it was felt that, were survival tested per rep, a statistical difference may have been found. This is due to the fact that, upon first glance at the mean rates of survival, family SW-1 had what appeared to be a noticeably lower rate of survival. This is an interesting observation, considering that SW-1 has low tolerance to salinity. Because the

difference in leaf size between families appeared to be minimal, the lower survival rate could, were it shown to be significant by rep, indicate a low nutritional value.

Unfortunately, were the FTLR survival on SW-1 statistically significant, it would not be likely to help advance restoration efforts because of its low tolerance for salinity. The FTLR may not destroy the seedlings, but the saltwater intrusion will. A balance between the two areas must be found if any impact on restoration efforts is to be made pertaining to insect survival.

Rate of development/development time is another important variable to note because it indicates how nutritionally fed the FTLR's are. Larvae that develop faster could be likely to consume more foliage. Statistically significant differences in development time were only found in the males of the population. Family CB-3, a salt-tolerant family, was found to have a statistically faster rate of development than all other families, with the exception of FA-2, which is the other salt-tolerant family.

It is important to note that the statistical difference shown here in the males of the population is not as relevant as a statistical difference in the females of the population would be. This is because it is the females that lay the eggs, and therefore have a greater influence on the population dynamics than do the males of the population. Additionally, earlier studies have shown that larger female pupae produce adults with higher rates of egg deposition.

Though no other statistically significant differences were found, there was a

hint of a trend, that with further experimentation, might be shown to be statistically significant in both the male and female analyses. It is possible that future studies may indicate that the FTLR's raised on the salt-intolerant families have longer development times than those raised on the intermediate tolerance families and salt-tolerant families, and that FTLR's reraed on salt-tolerant families have the shortest development time. This supposition matches the possible trend in the total survival analysis. If the FTLR's seem to live better on the more salt-tolerant varieties of baldcypress, this is not very good news for the coastal forest restoration effort. If they plant seedlings that are salt-tolerant, they may actually be benefitting some of the FTLR's.

Pupal weight was the last variable considered in this experiment. It is important because it is a measure of the overall fitness of the larvae. A statistically significant difference in pupal weight would indicate that FTLR's raised on one variety of baldcypress are actually more or less fit than those grown on another variety. The ANOVA results showed no such statistical differences. No trends were hinted, though it was noted that the smallest pupal weights were found in the salt-tolerant CB-3. Were this statistically significant, it might indicate that, because the development time of the larvae in this family was significantly faster and their pupal weights seemed to be lower, the larvae may be "forced" to pupate faster, because there are less nutrients available for consumption. Again, further research may

someday indicate statistical differences that that would show which families sustain the heavier, more fit, larvae. However, as the data stands at this time, no trend can be seen.

Conclusions

Much more needs to be learned concerning the coastal forest restoration before it can be ultimately successful. From the information gathered in this project, it appears that, in the future, experiments may be completed indicating that the FTLR may, in some ways, perform better on the more salt tolerant seedlings, which are the type that need to be planted in order to survive the saltwater intrusion present on the coastal lands of the Gulf of Mexico. Additional research may also someday find that he families that the FTLR does not perform well on salt-intolerant species that will not survive increasing salinity levels. More intensive study needs to be performed on the families of moderate tolerance, to find out if perhaps they will serve as good intermediates that can both tolerate increased salinity levels and somewhat inhibit the FTLR.

Summary

The coastal forests of the United States are being depleted as a result of several contributing causes, two of these being saltwater intrusion and FTLR defoliation. Restoration efforts have begun, but are not likely to succeed without a concerted effort to find varieties of baldcypress that are resistant to salinity and also less prone to FTLR attack. This experiment helps provide more understanding of the problem of the FTLR and its relationship to families of baldcypress differing in tolerance to salinity. Larvae were reared on six families of baldcypress differing in salinity tolerance. A significant difference was detected between the families in regard to development time. The males of the salt-tolerant family CB-3 developed faster than did the males reared on all other families except FA-2, the other salt-tolerant family. No other variables were statistically significant, though some hints of trends seemed to indicate that, with more extensive research, it may be found that, in some ways, larvae generally perform better on salt-tolerant species and worse on salt-intolerant species.

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APPENDIX

SAS OUTPUT

Analysis Variable : PERSURV

---------------------------------- FAMILY=cb3 --------------------------------

N Obs	N	Mean
1	1	76.3157895

---------------------------------- FAMILY=fa2 --------------------------------

N Obs	N	Mean
1	1	79.4871795

Analysis Variable : PERSURV

---------------------------------- FAMILY=sg2 --------------------------------

N Obs	N	Mean
1	1	71.4285714

---------------------------------- FAMILY=sw1 --------------------------------

N Obs	N	Mean
1	1	52.6315789

Analysis Variable : PERSURV

---------------------------------- FAMILY=sw2 --------------------------------

N Obs	N	Mean
1	1	75.0000000

---------------------------------- FAMILY=ve2 --------------------------------

N Obs	N	Mean
1	1	75.7575758

TABLE OF FAMILY BY COND

FAMILY	COND		
Frequency / Percent / Row Pct / Col Pct	alive	dead	Total
sw1	20	18	38
	8.97	8.07	17.04
	52.63	47.37	
	12.50	28.57	
Total	160	63	223
	71.75	28.25	100.00

(Continued)

TABLE OF FAMILY BY COND

FAMILY	COND		
Frequency / Percent / Row Pct / Col Pct	alive	dead	Total
sw2	30	10	40
	13.45	4.48	17.94
	75.00	25.00	
	18.75	15.87	
Total	160	63	223
	71.75	28.25	100.00

(Continued)

TABLE OF FAMILY BY COND

FAMILY	COND		
Frequency / Percent / Row Pct / Col Pct	alive	dead	Total
ve2	25	8	33
	11.21	3.59	14.80
	75.76	24.24	
	15.63	12.70	
Total	160	63	223
	71.75	28.25	100.00

TABLE OF FAMILY BY COND

FAMILY / COND Frequency Percent Row Pct Col Pct	alive	dead	Total
cb3	29 13.00 76.32 18.12	9 4.04 23.68 14.29	38 17.04
Total	160 71.75	63 28.25	223 100.00

(Continued)

TABLE OF FAMILY BY COND

FAMILY / COND Frequency Percent Row Pct Col Pct	alive	dead	Total
fa2	31 13.90 79.49 19.37	8 3.59 20.51 12.70	39 17.49
Total	160 71.75	63 28.25	223 100.00

(Continued)

TABLE OF FAMILY BY COND

FAMILY / COND Frequency Percent Row Pct Col Pct	alive	dead	Total
sg2	25 11.21 71.43 15.63	10 4.48 28.57 15.87	35 15.70
Total	160 71.75	63 28.25	223 100.00

STATISTICS FOR TABLE OF FAMILY BY COND

Statistic	DF	Value	Prob
Chi-Square	5	8.867	0.115
Likelihood Ratio Chi-Square	5	8.331	0.139
Mantel-Haenszel Chi-Square	1	0.396	0.529
Phi Coefficient		0.199	
Contingency Coefficient		0.196	
Cramer's V		0.199	

Sample Size = 223

FAMILY=CB-3 SEX=F

N Obs	Variable	N	Mean	Std Error
7	PUPWT	7	0.0455714	0.0020570
	DTIME	7	16.8571429	1.2988744

FAMILY=CB-3 SEX=M

N Obs	Variable	N	Mean	Std Error
14	PUPWT	14	0.0280000	0.0019527
	DTIME	14	13.2142857	0.8397970

FAMILY=FA-2 SEX=F

N Obs	Variable	N	Mean	Std Error
9	PUPWT	9	0.0486667	0.0015635
	DTIME	9	17.3333333	0.9128709

FAMILY=FA-2 SEX=M

N Obs	Variable	N	Mean	Std Error
21	PUPWT	21	0.0314762	0.0012547
	DTIME	21	14.5714286	0.5878590

FAMILY=SG-2 SEX=F

N Obs	Variable	N	Mean	Std Error
8	PUPWT	8	0.0487500	0.0024622
	DTIME	8	17.8750000	0.8114691

FAMILY=SG-2 SEX=M

N Obs	Variable	N	Mean	Std Error
19	PUPWT	19	0.0294737	0.000912449
	DTIME	19	16.1052632	0.6254577

FAMILY=SW-1 SEX=F

N Obs	Variable	N	Mean	Std Error
1	PUPWT	1	0.0530000	.
	DTIME	1	19.0000000	.

FAMILY=SW-1 SEX=M

N Obs	Variable	N	Mean	Std Error
13	PUPWT	13	0.0317692	0.0012616
	DTIME	13	16.4615385	0.6466421

FAMILY=SW-2 SEX=F

N Obs	Variable	N	Mean	Std Error
11	PUPWT	11	0.0461818	0.0014882
	DTIME	11	18.5454545	0.6923430

FAMILY=SW-2 SEX=M

N Obs	Variable	N	Mean	Std Error
17	PUPWT	17	0.0314118	0.0011116
	DTIME	17	17.1176471	0.7270122

FAMILY=VE-2 SEX=F

N Obs	Variable	N	Mean	Std Error
9	PUPWT	9	0.0505556	0.0021286
	DTIME	9	17.2222222	1.1027463

FAMILY=VE-2 SEX=M

N Obs	Variable	N	Mean	Std Error
15	PUPWT	15	0.0316667	0.0011198
	DTIME	15	16.2666667	0.6794022

UNIVARIATE PROCEDURE

Variable=PUPWT

```
                         Moments

     N               144  Sum Wgts        144
     Mean       0.036097  Sum           5.198
     Std Dev    0.009709  Variance   0.000094
     Skewness   0.480318  Kurtosis    -0.1887
     USS        0.201112  CSS        0.013479
     CV          26.8956  Std Mean   0.000809
     T:Mean=0   44.61697  Prob>|T|     0.0001
     Sgn Rank       5220  Prob>|S|     0.0001
     Num ^= 0        144
     W:Normal   0.949344  Prob<W       0.0001


                    Quantiles(Def=5)

      100% Max     0.061       99%      0.06
       75% Q3      0.043       95%     0.053
       50% Med     0.034       90%     0.052
       25% Q1       0.03       10%     0.025
        0% Min     0.017        5%      0.02
                                1%     0.018

      Range        0.044
      Q3-Q1        0.013
      Mode         0.033


                        Extremes

        Lowest    Obs     Highest    Obs
        0.017(     20)    0.057(     124)
        0.018(     12)    0.058(      55)
        0.018(     10)    0.058(      96)
        0.019(    107)     0.06(      53)
        0.019(     47)    0.061(     129)


 Stem Leaf                                         #             Boxplot
    6 01                                           2                |
    5 788                                          3                |
    5 0112223333344                               13                |
    4 5555667789                                  10                |
    4 00012233334444444                           17             +-----+
    3 55555555566667777888999                     23             |  +  |
    3 000011111111122222222233333333333334444444  42             *-----*
    2 5556666677788888999999                      22                |
    2 001244                                       6                |
    1 788999                                       6                |
      ----+----+----+----+----+----+----+----+--
  Multiply Stem.Leaf by 10**-2
```

UNIVARIATE PROCEDURE

Variable=PUPWT

```
                         Normal Probability Plot
0.0625+                                                         *  *
      |                                                     **++++
      |                                              ***+**++
0.0475+                                          ******+++
      |                                      ****+
      |                               ++*****
0.0325+                        ********
      |               ********+
      |           *****++
0.0175+*  *  ++*+*+
       +----+----+----+----+----+----+----+----+----+----+
           -2        -1         0        +1        +2
```


UNIVARIATE PROCEDURE

Variable=DTIME

Moments

N	144	Sum Wgts	144
Mean	16.25694	Sum	2341
Std Dev	3.051416	Variance	9.31114
Skewness	-0.26851	Kurtosis	-0.61731
USS	39389	CSS	1331.493
CV	18.76992	Std Mean	0.254285
T:Mean=0	63.93207	Prob>|T|	0.0001
Sgn Rank	5220	Prob>|S|	0.0001
Num ^= 0	144		
W:Normal	0.900292	Prob<W	0.0001

Quantiles(Def=5)

100% Max	21	99%	21
75% Q3	19	95%	21
50% Med	16	90%	19
25% Q1	14	10%	12
0% Min	9	5%	12
		1%	9
Range	12		
Q3-Q1	5		
Mode	19		

Extremes

Lowest	Obs	Highest	Obs
9(	60)	21(	118)
9(	31)	21(	119)
9(	10)	21(	120)

```
                    9(         9)        21(       128)
                    9(         8)        21(       129)


Stem Leaf                                          #             Boxplot
  21 00000000000000                               14                |
  20                                                                |
  19 000000000000000000000000000000000000000000   42             +-----+
  18                                                             |     |
  17                                                             |     |
  16 000000000000000000000000000000000000         36             *--+--*
  15                                                             |     |
  14 00000000000000000000000000000000             32             +-----+
  13                                                                |
  12 000000000000000                              15                |
  11                                                                |
  10                                                                |
   9 00000                                         5                |
     ----+----+----+----+----+----+----+----+--
```


UNIVARIATE PROCEDURE

Variable=DTIME

```
                          Normal Probability Plot
     21.5+                                     ********* * *
         |                                     +++
         |                               ***********
         |                                  +++
         |                               +++
         |                          *******
     15.5+                         ++++
         |                    ********
         |                     +++
         |               ********
         |                ++++
         |             +++
      9.5+* *****
          +----+----+----+----+----+----+----+----+----+----+
              -2        -1         0        +1        +2
```

------------------------------------ SEX=M ------------------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
FAMILY	6	CB-3 FA-2 SG-2 SW-1 SW-2 VE-2

Number of observations in by group = 99

------------------------------------ SEX=M ------------------------------------

General Linear Models Procedure

Dependent Variable: DTIME

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	162.19585928	32.43917186	4.23	0.0016
Error	93	713.21828213	7.66901379		
Corrected Total	98	875.41414141			

R-Square	C.V.	Root MSE	DTIME Mean
0.185279	17.73354	2.7692984	15.61616162

Source	DF	Type I SS	Mean Square	F Value	Pr > F
FAMILY	5	162.19585928	32.43917186	4.23	0.0016

Source	DF	Type III SS	Mean Square	F Value	Pr > F
FAMILY	5	162.19585928	32.43917186	4.23	0.0016

------------------------------------ SEX=M ------------------------------------

General Linear Models Procedure

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: DTIME

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 93 MSE= 7.669014
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 16.03882

Number of Means	2	3	4	5	6
Critical F	5.9121887	3.8253563	3.0217167	2.4695953	2.3123385

Means with the same letter are not significantly different.

REGWF Grouping		Mean	N	FAMILY
	A	17.118	17	SW-2
	A			
	A	16.462	13	SW-1
	A			
	A	16.267	15	VE-2
	A			
	A	16.105	19	SG-2
	A			
B	A	14.571	21	FA-2
B				
B		13.214	14	CB-3

General Linear Models Procedure

Ryan-Einot-Gabriel-Welsch Multiple Range Test for variable: DTIME

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 93 MSE= 7.669014
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 16.03882

Number of Means	2	3	4	5	6
Critical Range	2.3777981	2.5925529	2.7090375	2.7205626	2.8456751

Means with the same letter are not significantly different.

REGWQ Grouping		Mean	N	FAMILY
	A	17.118	17	SW-2
	A			
	A	16.462	13	SW-1
	A			
	A	16.267	15	VE-2
	A			
	A	16.105	19	SG-2
	A			
B	A	14.571	21	FA-2
B				
B		13.214	14	CB-3

NOTE: 60 obs hidden.

------------------------------------ SEX=F ------------------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
FAMILY	6	CB-3 FA-2 SG-2 SW-1 SW-2 VE-2

Number of observations in by group = 45

------------------------------------ SEX=F ------------------------------------

General Linear Models Procedure

Dependent Variable: DTIME

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	17.98502886	3.59700577	0.46	0.8068
Error	39	308.01497114	7.89781977		
Corrected Total	44	326.00000000			

R-Square	C.V.	Root MSE	DTIME Mean
0.055169	15.90739	2.8103060	17.66666667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
FAMILY	5	17.98502886	3.59700577	0.46	0.8068

Source	DF	Type III SS	Mean Square	F Value	Pr > F
FAMILY	5	17.98502886	3.59700577	0.46	0.8068

------------------------------------ SEX=F ------------------------------------

General Linear Models Procedure

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: DTIME

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 39 MSE= 7.89782
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 3.795094

Number of Means	2	3	4	5	6
Critical F	6.2232336	4.045492	3.202779	2.6123056	2.4558306

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	FAMILY
A	19.000	1	SW-1
A			
A	18.545	11	SW-2
A			
A	17.875	8	SG-2
A			
A	17.333	9	FA-2
A			
A	17.222	9	VE-2
A			
A	16.857	7	CB-3

General Linear Models Procedure

Ryan-Einot-Gabriel-Welsch Multiple Range Test for variable: DTIME

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 39 MSE= 7.89782
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 3.795094

Number of Means	2	3	4	5	6
Critical Range	5.0893901	5.5613487	5.8159742	5.8339127	6.112226

Means with the same letter are not significantly different.

REGWQ Grouping	Mean	N	FAMILY
A	19.000	1	SW-1
A			
A	18.545	11	SW-2
A			
A	17.875	8	SG-2
A			
A	17.333	9	FA-2
A			
A	17.222	9	VE-2
A			
A	16.857	7	CB-3

------------------------------------ SEX=M ------------------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
FAMILY	6	CB-3 FA-2 SG-2 SW-1 SW-2 VE-2

Number of observations in by group = 99

------------------------------------ SEX=M ------------------------------------

General Linear Models Procedure

Dependent Variable: PUPWT

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	0.00018059	0.00003612	1.35	0.2504
Error	93	0.00248773	0.00002675		
Corrected Total	98	0.00266832			

R-Square	C.V.	Root MSE	PUPWT Mean
0.067679	16.87085	0.0051720	0.03065657

Source	DF	Type I SS	Mean Square	F Value	Pr > F
FAMILY	5	0.00018059	0.00003612	1.35	0.2504

Source	DF	Type III SS	Mean Square	F Value	Pr > F
FAMILY	5	0.00018059	0.00003612	1.35	0.2504

------------------------------------ SEX=M ------------------------------------

General Linear Models Procedure

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: PUPWT

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 93 MSE= 0.000027
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 16.03882

Number of Means	2	3	4	5	6
Critical F	5.9121887	3.8253563	3.0217167	2.4695953	2.3123385

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	FAMILY
A	0.03177	13	SW-1
A			
A	0.03167	15	VE-2
A			
A	0.03148	21	FA-2
A			
A	0.03141	17	SW-2
A			
A	0.02947	19	SG-2
A			
A	0.02800	14	CB-3

Ryan-Einot-Gabriel-Welsch Multiple Range Test for variable: PUPWT

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 93 MSE= 0.000027
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 16.03882

Number of Means	2	3	4	5	6
Critical Range	0.0044408	0.0048419	0.0050595	0.005081	0.0053147

Means with the same letter are not significantly different.

REGWQ Grouping	Mean	N	FAMILY
A	0.03177	13	SW-1
A			
A	0.03167	15	VE-2
A			
A	0.03148	21	FA-2
A			
A	0.03141	17	SW-2
A			
A	0.02947	19	SG-2
A			
A	0.02800	14	CB-3

------------------------------------ SEX=F ------------------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
FAMILY	6	CB-3 FA-2 SG-2 SW-1 SW-2 VE-2

Number of observations in by group = 45

------------------------------------ SEX=F ------------------------------------

General Linear Models Procedure

Dependent Variable: PUPWT

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	0.00016973	0.00003395	1.05	0.4036
Error	39	0.00126307	0.00003239		
Corrected Total	44	0.00143280			

R-Square	C.V.	Root MSE	PUPWT Mean
0.118458	11.83962	0.0056909	0.04806667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
FAMILY	5	0.00016973	0.00003395	1.05	0.4036

Source	DF	Type III SS	Mean Square	F Value	Pr > F
FAMILY	5	0.00016973	0.00003395	1.05	0.4036

------------------------------------ SEX=F ------------------------------------

General Linear Models Procedure

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: PUPWT

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 39 MSE= 0.000032
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 3.795094

Number of Means	2	3	4	5	6
Critical F	6.2232336	4.045492	3.202779	2.6123056	2.4558306

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	FAMILY
A	0.05300	1	SW-1
A			
A	0.05056	9	VE-2
A			
A	0.04875	8	SG-2
A			
A	0.04867	9	FA-2
A			
A	0.04618	11	SW-2
A			
A	0.04557	7	CB-3

Ryan-Einot-Gabriel-Welsch Multiple Range Test for variable: PUPWT

NOTE: This test controls the type I experimentwise error rate.

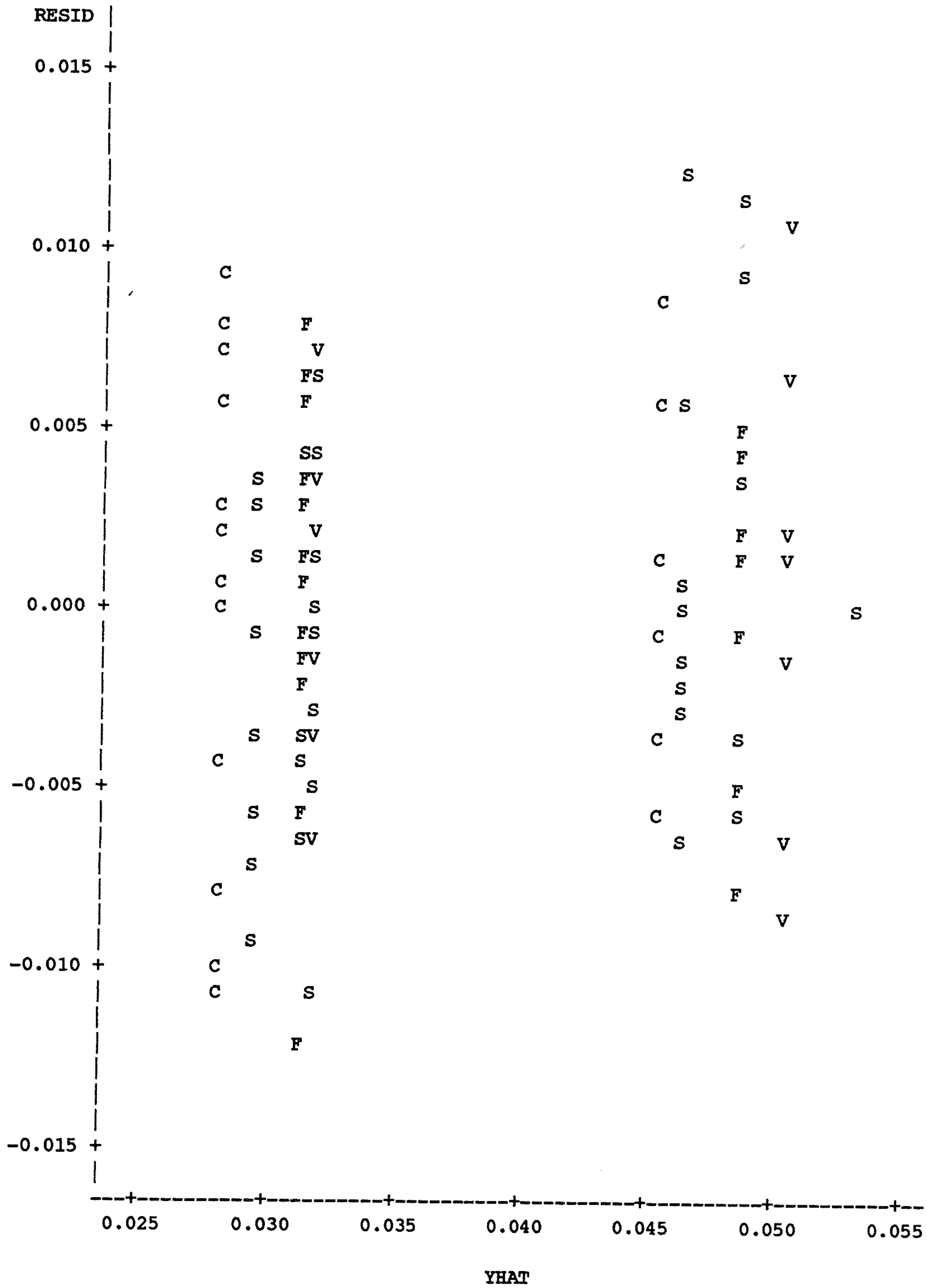
Alpha= 0.05 df= 39 MSE= 0.000032
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 3.795094

Number of Means	2	3	4	5	6
Critical Range	0.0103061	0.0112618	0.0117774	0.0118138	0.0123774

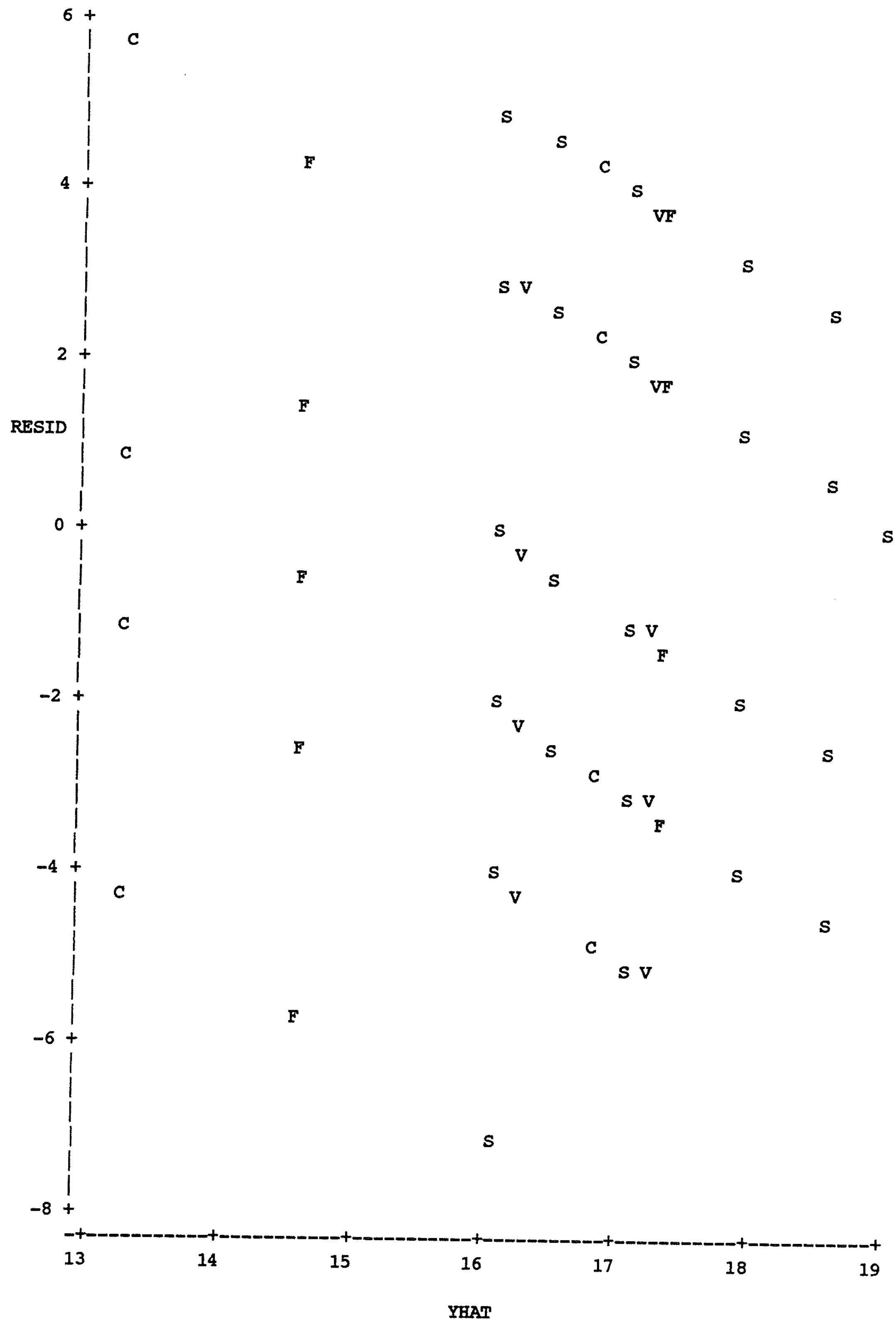
Means with the same letter are not significantly different.

REGWQ Grouping	Mean	N	FAMILY
A	0.05300	1	SW-1
A			
A	0.05056	9	VE-2
A			
A	0.04875	8	SG-2
A			
A	0.04867	9	FA-2
A			
A	0.04618	11	SW-2
A			
A	0.04557	7	CB-3

Plot of RESID*YHAT. Symbol is value of FAMILY.



Plot of RESID*YHAT. Symbol is value of FAMILY.



NOTE: 94 obs hidden.