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Statistical Analysis of Farmer Livestock Survey Data in the Mafraq Barley Cropping Region of Jordan

by

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STATISTICAL ANALYSIS OF FARMER LIVESTOCK SURVEY DATA IN THE MAFRAQ BARLEY CROPPING REGION OF JORDAN

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INTRODUCTION

Analyzed here is two years of data from a survey of farmers in the Mafraq region of Jordan in 1988 and 1989. The survey was conducted by Mahmoud Oglah, researcher at the International Center for Agricultural Research in the Dry Areas (ICARDA) at Aleppo, Syria and Dr. Abdullah Jaradat, Professor in the Department of Agronomy and Soils at the Jordan University of Science and Technology in Irbid, Jordan.

The emphasis in this analysis is on identifying and describing principal types of livestock operations (flock types) in the Mafraq area through statistical analysis of the survey data. Flock types are distinguished by composition of sheep and goats, geographic location, flock size, and quality of their diet.

Statistical relationships are established between indicators of flock productivity and characteristics of the flock. The analysis focuses on the relationship between productivity and the amount of high quality feed inputs. The statistical relationships are used in constructing livestock enterprise budgets for typical farm operations in the Mafraq region.

SURVEY AREA

The Mafraq barley cropping region is located in northeastern Jordan (Figure 1). Average annual precipitation in the region ranges from less than 200 millimeters (mm) in the East to slightly more than 400 mm in the West. Barley is the primary crop, wheat is a secondary crop, and both crops are usually alternated with a weedy, fallow that is grazed. Livestock (sheep and goats) is a key component of farming activity. Barley grain, barley tibin (chaff from threshing), grazed crop aftermath, and grazing in-lieu of harvest all provide feed inputs to the livestock operation. Livestock are also extensively grazed on common property steppe land.

The Mafraq area is divided into three precipitation zones (Figure one). In the western zone, annual precipitation ranges from just over 400 mm to 300 mm. While barley is the major crop, wheat is relatively important in the western area. The eastern zone receives less than 200 mm of annual precipitation. In the eastern zone, barley is the predominate crop and wheat is relatively unimportant. The central (transitional) zone receives from 200 to 300 mm of annual precipitation and has a mixture of the cropping patterns found in the eastern and western regions.

The survey of the Mafraq region included 114 farmers--23 from the western zone, 61 from the central, and 30 from the eastern zone. An extensive discussion of survey results can be found in Oglah and Jaradat and in Jaradat, Oglah and Tutwiler. Our analysis is confined to responses from 89 farmers who owned livestock.

TYPICAL FLOCK TYPES

One goal of the analysis is to establish typical flock types for the three rainfall zones delineated in the survey. Flocks were classified as: 1) goats only; 2) flocks that are a mixture of goats and sheep; and 3) flocks where sheep predominate, i.e., at least 90 percent of the flock is sheep. The division in flock types is constructed partly to account for higher milk production by goats as compared to sheep. Also, there are some differences in the grazing habits of goats and sheep. A possible source of bias in estimating productivity is eliminated by controlling for flock type.

Flock types tended to follow a geographic pattern with goats concentrated in the western (wetter) rainfall zone as shown in Table 1. For example, the majority of goat only flocks are found in rainfall zone one (ten out of sixteen) where they tend to predominate.

On the other hand, mixed livestock and sheep flocks tend to be concentrated in the drier central and eastern zones.

Covariance analysis also shows a high interaction effect between flock type and rainfall zone (Table 2). For example, more goat flocks are found in the western zone and less in the other two zones than would be expected assuming an independent relationship between flock type and zone. Mixed flocks are also concentrated in the western zone while the number of sheep flocks in the zone is less than expected given an independent relationship. On the other hand, covariance analysis for the central and eastern zones only (deleting the western rainfall zone) shows no interaction between flock type and rainfall zone. These results imply that flock types on the central and eastern farms are relatively homogeneous with mixed flocks and sheep flocks predominating.

PRODUCTIVITY PER DOE AND EWE ANALYSIS

Productivity per head of adult females (does and ewes) is measured in terms of milk productivity and total productivity. Milk productivity is measured in quantity of milk produced per head and is obtained by dividing the reported amount of milk production by the number of ewes and does in the flock. Total productivity is the total value of milk and young stock produced per head. Total production equals the number of lambs and kids produced in the survey years multiplied by their average selling prices plus all milk production valued at an average selling price.

These measures of productivity are compared to various independent variables using regression analysis to obtain possible explanations for differences in livestock productivity between farms. Particular interest is placed on the relationship between

livestock productivity and diet. Livestock given higher levels of high quality feeds (barley grain, barley straw, wheat bran, and lentil straw) should be more productive than livestock fed on poorer quality diets. Once statistical relationships have been established between diet and productivity, one can begin to compare the profitability of different levels of diet.

Analysis relating measures of productivity to each of the different types of hand fed high quality inputs such as barley grain and wheat bran would be difficult to interpret. The difficulty occurs because farmers may substitute among these inputs and use different combinations of feeds to obtain a given level of quality and quantity in the diet of their livestock. To remove this problem, all hand fed inputs are converted to their energy and protein equivalents. These energy and protein equivalent values are then summed to form total energy and total crude protein from hand-fed sources. Because crude protein per head is highly correlated with energy per head, only the energy values are used as an independent variable in attempts to explain variation in livestock productivity.

RESULTS OF MILK PRODUCTIVITY ANALYSIS

Milk production of sheep and goats is related to feed energy intakes per head, area of cropland seeded to cereal grains per head, and total costs of purchased inputs per head in both simple and multiple regressions. Linear, log-linear, and non-linear exponential functional forms are used in examining the relationship between milk productivity and these independent variables.

MILK PRODUCTIVITY AND AREA MEASUREMENT VARIABLES

Milk productivity (MP) is compared to several measures of cropping activity such as barley area seeded (BAS), area seeded in winter cereals (WCH), and total cultivated area (CLH) (Figure 2), all measured per head of adult females. These crop area variables represent additional information about sources of high quality feed not entirely reflected in the survey data. Areas in winter cereals are grazed after harvest (aftermath grazing) and this grazed stubble is fairly high in nutrient content (Pannell). Grazing instead of harvesting a crop is also a common practice in the region, especially when grain yields are low (Nordblom). Area seeded in winter cereals is chosen as the best proxy variable for unmeasured high quality feed inputs based on goodness of fit measures for simple regressions with milk productivity as the dependent variable.

Milk productivity per head (MP) is regressed against energy content of hand-fed feeds (EPH) and winter cereal area (WCH) in a multiple linear regression (Figure 2). EPH is highly significant (t value = 2.854 significant at the .995 confidence level) while WCH is somewhat significant at a lower level of confidence. Overall fit tends to be fairly good for all the flock types, with R^2s varying from .24 for sheep flocks to .41 for mixed goat and sheep flocks. The relationship between MP and the two independent variables does vary by flock type with EPH highly significant and WCH insignificant for goats and mixed flocks. For sheep flocks, WCH is highly significant and EPH explains relatively little variation in milk productivity.

A final multiple regression equation includes total costs of monetary expenditures per head (TCH) in addition to winter cereal area and energy per head. In separate simple

linear regressions, TCH proved to be highly significant in explaining variations in milk productivity (Figure 2).

The linear multiple regression of milk production per head (MP) versus total costs (TCH), energy (EPH), and winter cereal per head (WCH) yields a highly significant F value of 6.318 (Figure 2). WCH has some influence on MP while TCH has a highly significant relationship with MP. The insignificant t value (0.681) for EPH is suspect because of its high collinearity with TCH (the correlation between the beta values for the two variables is -0.63). The collinearity between total cost per head and energy per head is expected because purchased feeds provide a significant portion of total feed energy as well as being the major component of farmer expenditures on livestock.

A nonlinear exponential regression using the same variables yields a slightly higher r value (.45) than the linear model (r equal to .44) (Figure 2). The relationship between WCH and MP is of the wrong sign in the nonlinear regression; however, both EPH and TCH meet apriori expectations by having positive beta values with significant asymptotic t values. The nonlinear exponential equation implies that milk production is increasing at a slightly increasing rate.

TOTAL PRODUCTIVITY RESULTS

Total productivity of livestock is also evaluated in this study. Production of milk and of kids and lambs are both components of total productivity. Separate analysis of meat and milk production does not adequately measure total productivity because animals productive in one may not necessarily be productive in the other. Total productivity includes both meat and milk production. In this study, total productivity is measured by

summing economic value of meat (lamb and kid) and milk production. The number of kids, lambs, and milk produced by a given flock are multiplied by the average price received by farmers for these outputs. The results are summed into one value and divided by the total number of ewes and does in the flock to yield a measure of total livestock productivity. The contribution of milk production to total productivity is relatively small (32.4 percent) as compared to the contribution of meat production (32.8 percent for kids and 34.8 percent for lambs).

Statistical measures of differences in total productivity between flock types and between rainfall zones are shown in Table 3. Analysis of variance (ANOVA) results indicate a significant difference in total productivity per head (TPH) between flock types. The mean total productivity for mixed flocks is highest. Flocks with mostly sheep have the lowest mean of 30.34 Jordanian Dinar (JD) per head. On the other hand, ANOVA results present little evidence for significant difference in TPH between rainfall zones, although results are suspect because the assumption of homogeneous variance between the three groups is violated (Steele and Torre).

Results where differences in productivity between rainfall zones are examined while flock type is held constant also tend to support the conclusion that productivity does not vary between rainfall zones (Table 4). For example, mixed flocks of sheep and goats show no significant differences in mean total productivity between rainfall zones (F value equals .155).

The relationship between total productivity per head (TPH) and energy per head (ewe and doe) (EPH) is examined under linear, log-linear, and exponential functional

forms. All functional forms show a significant relationship between TPH and EPH. However, the linear and exponential functional forms provided the best fits as seen in Figure 3. Based on results from the simple linear regression, two observation that are statistical outliers were dropped from the total productivity and energy per head analysis. While the simple linear regression provided reasonably good fits, the exponential functional form resulted in a higher r value (.67 versus .58 for the linear equation). The better fit of the exponential function tends to hold across all flock types and rainfall zones. For example, for sheep flocks, the exponential relationship shows a r value of .81, and an asymptotic t of 30.0 for the energy per stock variable, versus an r value of .57 for the linear regression.

The better fit for the exponential relationship between energy per head (EPH) and total productivity per head (TPH) occurs because it provides more accurate predictions when EPH and TPH are both at relatively high levels (Figure 4). The total productivity of the ewe or doe increases at an increasing rate as total feed energy per head increases (marginal productivity is increasing) under the exponential functional form. Apparently, livestock production in Mafraq is now in stage I of the production function. Marginal productivity per head would be expected to eventually show constant and then decreasing returns to high quality feed inputs, as in the standard three-stage production function.

Total productivity per head (TPH) is also regressed against total costs (TCH), energy (EPH), and winter cereal per head (WCH). TCH is dropped from the set of multiple regression equations because of high collinearity between TCH and EPH. The

exponential functional form was chosen over a linear equation form because of the better fit it provided in the previously discussed equations where EPH is the only independent variable. Both WCH and EPH are both significant in the overall nonlinear equation with asymptotic t values of 6.29 and 30.0 as demonstrated in Figure 3. The correlation coefficient (r value) for the equation is .72. Both variables tend to be highly significant, and model fit tends to be fairly good, across precipitation zones and also between flock types. The equation predicts quite well for mixed flocks for example, with an r value of .83. For flocks in the western cropping zone and goat flocks in any zone, the coefficient of winter crop area per head (WCH) is insignificant.

The previously noted difference in productivity between flock types is not explained by differences between the three flocks types in levels of energy per head, total costs per head, or winter crop area per head (Table 5). Analysis of variance results shows no significant difference between flock types for any of the three measures.

An alternative explanation is that for very large flocks, per unit animal productivity tends to decline and sheep flocks may tend to be larger than mixed flocks and goat flocks. For example, regression results given in Figure 3 imply a significant although not extremely important relationship between total number of livestock and total productivity per head. To test the relationship between flock size and productivity, the sample is divided into quartiles based on its distribution by flock size (total number of ewes and does). Covariance analysis implies that large flocks (in the size ranges of 60 through 144 head or 145 through 486 head) tend to predominate for sheep flocks while smaller flocks (1 through 24 head and the 25 through 59 head) tend to predominate for goat flocks

(Table 6 and Table 7). Analysis of variance (ANOVA) results demonstrate, however, that total productivity does not significantly vary between the four size categories as shown in Table 8. Accordingly, differences in flock size at most explain only a small amount of the difference in productivity between the three flock types.

CONCLUSIONS

Several tentative conclusions can be drawn from the analysis of survey data from farmers in the Mafraq region of Jordan. First, sheep flocks tend to be less productive than mixed flocks of sheep and goats and goat flocks. A small portion of the difference in productivity may be caused by higher milk production of goats as well as the larger size of the average sheep flock. However, attempts to explain the difference in productivity between sheep flocks and the other two flock types are largely unsuccessful. Differences are not discerned between flock types for variables, such as energy per head, that apparently explain some of the variation in total productivity between farms.

Second, statistically significant relationships are established between livestock productivity and feed-supply variables such as energy per head and area in winter cereal crops per head. The feed variables explain a good deal of the variation in total productivity. The unexplained portion of total productivity and the inability to explain why sheep flocks are on average less productive than other flock types implies a need for additional research. Controlled studies of animal production of lambs, kids, and milk would better define the relationship between high quality inputs and livestock productivity. Such studies would also help determine if the finding concerning the actual

productivity of flock types is an aberration of the survey or if it actually holds for flocks in the Mafraq region of Jordan.

The analysis is intended to provide information to be used in constructing budgets for typical flocks in the Mafraq region of Jordan. In this regard, budgets are built for three types of flocks: 1) goat only flocks located in the western precipitation zone; 2) ewe and goat flocks found through out the Mafraq region; and 3) ewe flocks located in either central or western precipitation zones.

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TABLE 1. Distribution of Farm Livestock Flock Types by Rainfall Zone in the Mafraq Region of Jordan

Flock Types	Rainfall Zone			
	Western	Central	Eastern	Total
Goats	10	5	1	16
Sheep and Goats	6	15	10	31
Sheep	3	25	14	42
Total	19	45	25	89
Percent Goats	47	7	16	14
Percent Sheep	53	93	84	86

NOTE: Percents by goats and sheep equal the number of goats and the number sheep in each zone divided by the total number of livestock in the zone.

TABLE 2. Distribution of flock Types by Rainfall zones in the Mafraq Region, Predicted Values and Standardized Residuals.

Flock Type	Rainfall Zone		
	Western	Central	Eastern
GOATS			
Predicted Residuals	3.92	8.82	5.05
	(3.37)	(-1.09)	(-1.54)
SHEEP AND GOATS			
Predicted Residuals	7.23	16.26	9.31
	(-0.23)	(-0.16)	(0.42)
SHEEP			
Predicted Residuals	9.65	21.71	12.43
	(-1.95)	(0.83)	(0.61)

Test of Model Fit:	Independence Probability
Degrees of Freedom = 4	
Pearson Chi-Square = 20.03	0.000
Likelihood Ratio Chi-Square = 18.57	0.001

NOTE: Standardized Residuals equal the observed value minus the fitted value divided by the square of the fitted value. A change value of 0.6 was added to each fitted value to eliminate sparse fitted values. Probabilities for Pearson and Likelihood Ratio Chi-Square indicate the likelihood of independence between rainfall zone and flock type.

TABLE 3. Analysis of Variance (ANOVA) of Total Productivity Between the Three Flock Types and Between the Three Rainfall Zones in the Mafraq Region

	Test Results			
	Mean	Variance	Test	Probability
FLOCK TYPES				
Goats	42.5	420.2		
Sheep and Goats	50.8	733.3		
Sheep	30.4	819.3		
F-test			5.178	0.008
Chi-Square			2.143	0.342
RAINFALL ZONES				
Eastern	42.1	174.9		
Central	38.3	954.6		
Western	40.1	1016.1		
F-test			0.127	0.881
Chi-Square			14.459	0.001

NOTE: For the F-test, the probability indicates the likelihood of no significant difference in total productivity between flock types and between rainfall zones. The probability for the Chi-Square value (Bartlett test for homogeneity of group variance) shows the likelihood of no significant difference in variance of total productivity between flock types and between rainfall zones.

TABLE 4. Analysis of Variance (ANOVA) of Total Productivity for Mixed and Sheep Flock Types Across the Three Rainfall Zones in the Mafraq Region

Flock Type	Rainfall Zone			Test Results	
	Western	Central	Eastern	Test	Probability
Sheep and Goats:					
Mean	46.1	53.4	49.8		
Variance	117.7	1295.4	287.6		
F-Test				0.155	0.857
Chi-Square				10.289	0.007
Sheep:					
Mean	---	27.6	35.6		
Variance	---	531.1	1492.8		
T-statistic				-0.802	0.428
Chi-Square				4.538	0.033

NOTE: For the F-test, the probability indicates the likelihood of no significant difference in total productivity between rainfall zones. The probability for the Chi-Square value (Bartlett test for homogeneity of group variance) shows the likelihood of no significant difference in the variance of total productivity between rainfall zones.

TABLE 5. Analysis of Variance (ANOVA) of Key Livestock Inputs for All Flock Types in the Mafraq Region

	Flock Type			Test Results	
	Goats	Mixed	Sheep	Test	Probability
ENERGY PER HEAD					
Mean	2146.3	1951.2	2207.9		
Variance	1791844	2419670	2292044		
F-test				0.268	0.776
Chi-Square				0.441	0.802
TOTAL COST PER HEAD					
Mean	12.65	9.53	11.44		
Variance	86.91	56.47	50.82		
F-test				1.004	0.371
Chi-Square				1.716	0.424
WINTER CEREAL AREA PER HEAD					
Mean	3.26	3.80	2.44		
Variance	9.47	22.29	11.35		
F-test				1.145	0.323
Chi-Square				5.420	0.067

NOTE: For the F-test, the probability indicates the likelihood of no significant difference between flock types for each variable. The probability for the Chi-Square value (Bartlett test for homogeneity of group variance) shows the likelihood of no significant difference in the variance of each variable between flock types.

TABLE 6. Distribution of Farm Livestock Flock Types by Flock Size Category in the Mafraq Region of Jordan

Flock Type	Size Category				
	One	Two	Three	Four	Total
Goats	9	6	1	0	16
Sheep and Goats	8	10	8	5	31
Sheep	6	6	13	17	42
Total	23	22	22	22	89

NOTE: Size category one contains all flocks with 1 through 24 members; size category two includes flocks with 25 through 59 ewes and does; size category three contains flocks with 60 through 144 ewes and does; and size category four contains flocks with 145 through 486 members.

TABLE 7. Distribution of Farm Livestock Flock Types by Flock Size Category in the Mafraq Region of Jordan; Predicted Values and Standardized Residuals

	Size Category			
	One	Two	Three	Four
GOATS				
Predicted Residuals	5.2	5.0	5.0	5.0
	(2.13)	(0.92)	(-1.32)	(-1.77)
SHEEP AND GOATS				
Predicted Residuals	9.06	8.71	8.71	8.71
	(-0.00)	(0.79)	(0.11)	(-0.90)
SHEEP				
Predicted Residuals	11.89	11.44	11.44	11.44
	(-1.40)	(-1.30)	(0.77)	(1.96)

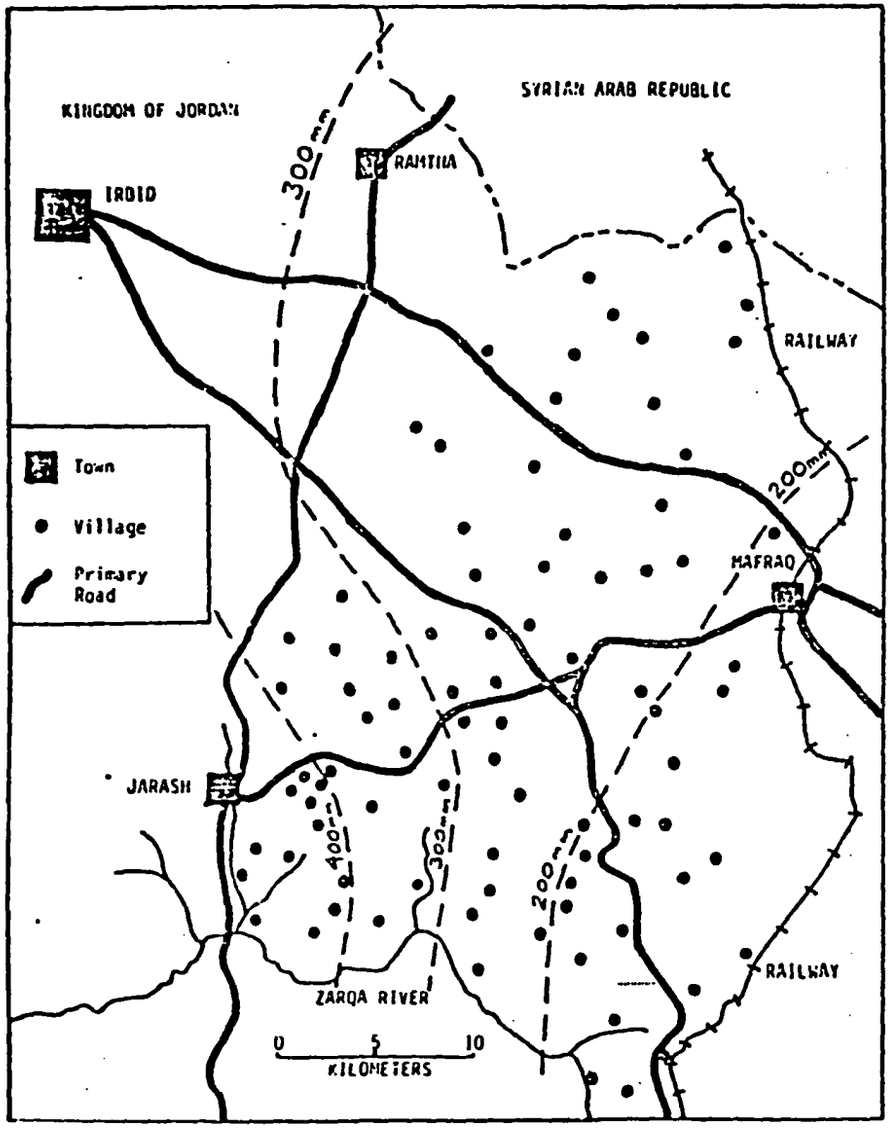
Test of Model Fit:	Independence Probability
Degrees of Freedom = 6	
Pearson Chi-Square = 19.76	0.003
Likelihood Ratio Chi-Square = 20.73	0.002

NOTE: Standardized Residuals equal the observed value minus the fitted value divided by the square of the fitted value. A change value of 1.05 was added to each fitted value to eliminate sparse fitted values. Probabilities for Pearson and Likelihood Ratio Chi-Square indicate the likelihood of independence between rainfall zone and flock type.

TABLE 8. Analysis of Variance (ANOVA) of Total Productivity by Flock Size Category in the Mafraq Region

Size Category	Mean	Variance	Test Results: Test	Test Results: Probability
One	42.5	420.2		
Two	50.8	733.3		
Three	30.4	819.3		
Four				
F-test			0.543	0.657
Chi-Square			1.411	0.238

NOTE: Size category one contains all flocks with 1 through 24 members; size category two includes flocks with 25 through 59 ewes and does; size category three contains flocks with 60 through 144 ewes and does; and size category four contains flocks with 145 through 486 members. For the F-test, the probability indicates the likelihood of no significant difference in total productivity between the flock size categories. The probability for the Chi-Square value (Bartlett test for homogeneity of group variance) shows the likelihood of no significant difference in the variance of total productivity between the flock size categories.



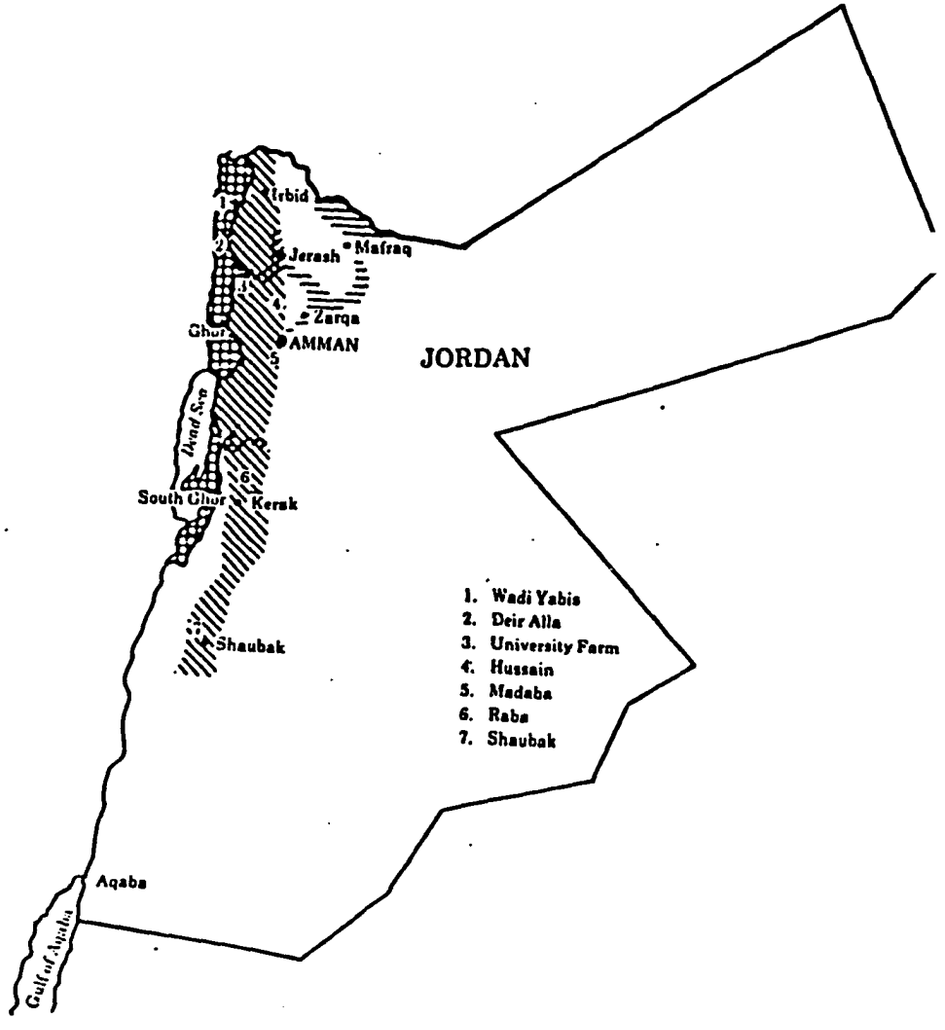


Figure 1. Location of the Three Rainfall Zones in the Mafraq Farming Region of Jordan

FIGURE 2. Milk Productivity of Livestock of Surveyed Farmers in the Mafraq Region of Jordan

Milk Production per Head versus Cropping Area Independent Variables:

MP = 40.234 + 0.537 CLH
(8.574) (1.529)

R2 = .026
r = .162
Durbin Watson = 1.478

MP = 44.762 - 0.443 BAH
(8.409) (-0.238)

R2 = .001
r = .026
Durbin Watson = 1.394

MP = 38.347 + 1.931 WCH
(7.447) (1.856)

R2 = .038
r = .195
Durbin Watson = 1.405

Milk Production Per Head versus Total Expenditures per Head:

MP = 24.857 + 1.736 TCH
(3.721) (3.480)

R2 = .122
r = .350
Durbin Watson = 1.869

Milk Production Per Head versus Energy per Head, Winter Crop Area Seeded per Head, and Total Expenditures per Head:

MP = 21.095 + 1.509 WCH + .008 EPH
(2.824) (1.471) (2.854)

R2 = .124
r = .353
F = 5.827
Durbin Watson = 1.709

MP = 14.155 + 1.488 WCH + .002 EPH + 1.678 TCH
(1.833) (1.498) (0.681) (2.552)

R2 = .190
r = .435
F = 6.318
Durbin Watson = 1.274

MP = 33.913 + e(-.2122 WCH + .0003 EPH + .118 TCH)
(8.35) (-2.27) (2.80) (5.28)

r = .445

Milk Production Per Head versus Energy per Head, Winter Crop Area Seeded per Head, and Total Expenditures per Head, by Flock Type:

Goats:

MP = 58.723 - 3.251 WCH + .0184 EPH
(2.151) (-0.846) (2.078)

R2 = .319
r = .565
F = 3.047

Sheep and Goats:

MP = 13.777 + 1.075 WCH + .0103 EPH
(1.977) (1.221) (3.769)

R2 = .410
r = .641
F = 9.398

Sheep:

MP = 14.746 + 3.112 WCH + .0023 EPH
(2.230) (3.029) (0.960)

R2 = .244
r = .494
F = 5.811

FIGURE 3: Total Productivity of Livestock of Surveyed Farmers in the Mafraq Region of Jordan

Total Productivity Per Head versus Energy Per Head

$$TP = 22.078 + 0.0087\ EPH$$
(4.350) (4.407)

N = 89
R2 = .182
r = .427
Durbin Watson = 1.801

$$TP = 16.195 + 0.0112\ EPH$$
(3.716) (6.531)

N = 87
R2 = .334
r = .578
Durbin Watson = 2.293

$$TP = 31.50 + e(0.00066\ EPH)$$
(13.462) (33.0)

N = 87
r = .673

Total Productivity Per Head versus Energy Per Head Overall and by Rainfall Zone

Overall:

$$TP = 30.65 + e(0.08069\ WCH + 0.0006\ EPH)$$
(-0.10) (5.63)

r = 0.72

Western:

$$TP = 38.10 + e(-0.02423\ WCH + 0.00053\ EPH)$$
(10.563) (-0.10) (5.63)

r = .383

Central:

$$TP = 27.59 + e(0.08707\ WCH + 0.00058\ EPH)$$
(10.563) (7.08) (22.23)

r = .743

Eastern:

$$TP = 27.15 + e(0.31924\ WCH + 0.00052\ EPH)$$
(5.875) (4.09) (5.63)

r = .823

Total Productivity Per Head versus Energy Per Head, by Flock Type

Goats:

$$TP = 36.66 + e(0.0622033\ WCH + 0.00057\ EPH)$$
(5.90) (0.39) (5.19)

r = .396

Sheep and Goats:

$$TP = 40.91 + e(0.08204\ WCH + 0.00056\ EPH)$$
(13.633) (7.18) (23.38)

r = .831

Sheep:

$$TP = 19.49 + e(0.09978\ WCH + 0.00066\ EPH)$$
(6.926) (4.12) (30.0)

r = .812

Total Productivity Per Head versus Flock Size

$$TP = 46.016 - 0.0551\ FLH$$
(10.669) (-1.917)

R2 = .041

NOTE: T-values and asymptotic t-values are in parenthesis.

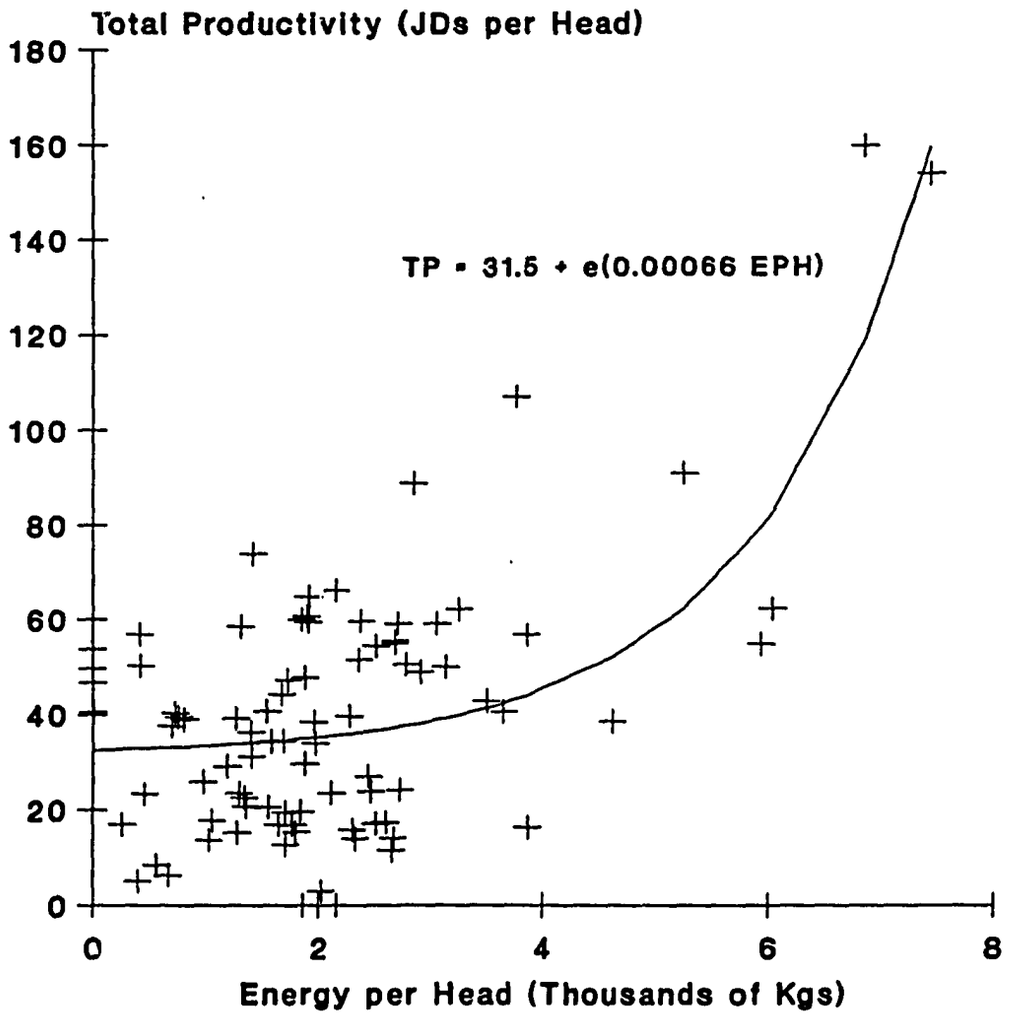


Figure 4. Nonlinear Regresion of Total Productivity versus Energy

+ Observed Values