ORGAN WEIGHT-BODY WEIGHT INTERRELATIONSHIPS IN THE FAMILY MUSTELIDAE: (ORDER CARNIVORA.)

by

Michael John Daniel,

B.A., University of British Columbia, 1957.

A Thesis Submitted in Partial Fulfilment

of the Requirements for the Degree of

MASTER OF SCIENCE

in the Department of Zoology.

We accept this thesis as conforming to the required standard.

THE UNIVERSITY OF BRITISH COLUMBIA

APRIL, 1959

ABSTRACT

The main objective of this study was to draw up prediction tables of presumably "normal" organ weights from the computed regression equations for the following species of the family Mustelidae: Mustela vison, Martes americana, and Martes pennanti. These tables would be of value to the pathologist, the nutritionist, and to the wildlife biologist interested in these important fur-bearers.

The ranch mink used in this study were sacrificed by two methods. One hundred by hydrogen cyanide and ninety-six by electrocution. Histological sections of the organs were prepared to compare the effects of these two methods.

It was found that there was no significant sex difference in the equations for the cyanide sacrificed mink. The electrocuted mink, however, showed marked sex differences with the exponents of the females being from 3-5 times those of the males. Histological sections showed this to be due to differential engorgement.

The mink were found to have relatively lighter hearts and lungs than both of the other Mustelids and the predicted values of Brody. The adrenal glands of the mink were also well below those of the marten and fisher and Brody's figures.

The weights of the thyroid and parathyroid glands of the marten and fisher were also well below those predicted by Brody.

The regression of organ weight and body weight gave high correlations in the three species studied for the heart, lungs, kidney, liver and stomach. Low correlation coefficients were found for the spleen, adrenal glands, thyroid and parathyroid glands and the testes.

The heart weight, being the organ least affected by changing physiological conditions in an animal, is tentatively proposed as a new base line against which to express the other organ systems.

In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the Head of my Department or by his representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Department of Zoology:

The University of British Columbia,
Vancouver 8, Canada.

Date April, 1959.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES.

LIST OF PHOTOMICROGRAPHS.

ACKNOWLEDGEMENTS

The writer wishes to extend his sincere gratitude to Dr David Fowle, Dr Audrey Fyvie and Mr R. O. Standfield, of the Division of Research, Department of Lands and Forests, Maple, Ontario, for supplying the marten and fisher used in this study and for generously allowing me to collect data on the Mustelidae while working on a problem of beaver ecology.

To Dr I. McT. Cowan, Department of Zoology, and Dr A. J. Wood, Department of Animal Science, University of British Columbia, go my sincere thanks for their support and encouragement throughout this study.

For the histological sections I wish to thank Miss Sachiko Tabata, and for the photomicrographs my thanks to to Mr Lin Kemp.

ORGAN WEIGHT-BODY WEIGHT INTERRELATIONSHIPS IN THE FAMILY MUSTELIDAE. (ORDER CARNIVORA.)

Introduction

The interrelationship existing between the organ weights and the body weights of many animals has been the subject of numerous publications in the last fifty years. Addis and Gray (I950), Hatai (I9I3) and Brody (I945). The value of such data to students of pathology and nutrition is beyond question. The lack of such data for the mink, Mustela vison, has handicapped investigations on this important species. For example, before one can interpret the changes which arise coincident with nutritional deficiency states or infectious diseases, one must have a "normal" standard against which which these changes can be expressed. For this reason during the last few years we have collected what might be termed "normal" organ weights for the mink. A preliminary report on this mink data has been recorded. Daniel (I957). The present work was designed to extend the earlier study with the aid of more refined statistical procedures and to permit a comparison of this species with other members of the Family Mustelidae; the marten, Martes americana, and the fisher, Martes pennanti. Sufficient numbers of the otter, Lutra canadensis, and the shorttail weasel, Mustela erminea, were not available to warrant the application of statistical methods of analysis.

Many methods have been suggested to give mathematical expression to the organ weight-body weight interrelationship. The so-called growth parabola, which may be expressed by the equation, $Y = aX^b$, has been used in biology for over one hundred years (Brody, I945). Since I89I it has been used for quantitative expression of organ systems.

In 1895 DuBois and Lapicque used this equation for relating the brain weight of different species to their body weight. They found a linear distribution of such data on logarithmic grids which yielded a slope of 0.56 when body weight was the independent variable. They showed that although the value of the slope "b" was the same for many species, the value of the y-intercept "a" was the highest for man, next for the anthropoid apes and so on down the supposed scale of evolution. Lapicque called this constant "a" the cephalization coefficient.

Hatai (1913), used the parabola to express organ weight-body weight interrelationships in rats. However it was not until 1932 that the parabola received wider attention when Huxley (1932) made use of this simple exponential relationship to illustrate the heterogonic nature of the growth processes. Huxley and Teissier (1936), gave it the name, the allometric equation, implying the equation by which anything can be measured. The form used by Huxley was as follows: $Y = bX^k$, where "b" is the y-intercept and called by him the fractional coefficient. This constant may be of doubtful biological significance. For the present purposes it is better left with its mathematical meaning as the y-intercept for the regression equation. The constant "k" is the exponent, which is the value of the slope of the log log regression line.

More recently Sholl (1954), has pointed out that the allometric equation plotted on double logarithmic paper will tend to straighten out a wide variety of curves.

Since 1932, Brody (1945) and Addis and Gray (1950) have found the parabola to be effective for the quantitative expression of organ systems. It is appreciated that this method of expression is inadequate to relate certain of the endocrine glands and the gonads to body weight. Brody (1945).

For purposes of clarity the objectives of this study may be enumerated as follows:

1. To draw up prediction tables based on regression equations for the various organs of the three species. These supposedly "normal" values should be of value to the mink rancher, the pathologist, the nutritionist and the wildlife biologist who may be interested in these important furbearers.

2. To compare the possible differential premortem effects of electrocution and cyanosis on the visceral organs of the mink.

3. To ascertain if there are any significant sex differences in the regression equations for any of the organs, as have been reported for some organs, notably the adrenal gland and the gonads in the growing rabbit by Kibler and Bergman (1943).

4. To ascertain if any "breaks" or atypical curves occur in the regression equations for any of the organs, which may be a reflection of more profound physiological changes. "Breaks" have been reported for the kidneys in cats, (Brody 1945), in the testes and ovaries and adrenals of rabbits by Kibler (1943) and in the gonads and adrenals of growing guinea pigs by Mixner and Bergman (1943).

5. To examine how the relative organ weights of these three species reflect the physiological adaptations of each to its own "ecological niche". It is to be expected that the adaptations in the relative size of some of the organs in the mink, a semi-aquatic species, would differ from the relative sizes of the

same organs in the marten and fisher which are active terrestrial and at times semi-arboreal species of Mustelid.

SOURCES OF MATERIAL

1. Mink *Mustela vison*

Ranch mink were used in this study. The animals were obtained in December 1956 during the normal pelting season. One sample consisted of one hundred mink killed by exposure to hydrogen cyanide gas. They were from the ranch of Mr R. C. Collings. The other sample of ninety-six mink killed by electrocution were procured from the University of B.C. experimental ranch. The electrocution was carried out with the standard trap used by mink ranchers, using a 110 volt, 15 ampere A.C. current. These two methods are the most common used to-day by the ranch mink industry. This sample contained adults of both sexes and kits of the year. A breakdown of the two samples by sex and colour phase is given in Table I.

Table I A Breakdown of the Mink Sample into Sex and Colour Phase

	Males	Females	Total
100 Cyanide killed mink			
Pastel	20	30	50
Standard	16	14	30
Sapphire	7	9	16
Arctic	1	-	1
Homo.	1	-	1
Blond.	1	-	1
½-Standard	1	-	1
96 Electrocuted mink			
Standard	44	26	70
Pastel	20	1	21
½-Palomino	-	2	2
Silver-blu	-	2	2
B.C. Mink	1	-	1

2. Marten. Martes americana

The marten are wild trapped animals from northern Ontario, obtained from commercial trappers in the season of 1956-57. The animals were collected by district biologists and sent to the Southern Research Station at Maple, Ontario. They were stored there at zero degrees F. A total of forty-four marten were used in this study, comprising thirty-one males and thirteen females. Both adults and kits of the year were represented in the sample. As far as is known these animals were all killed by exposure in steel traps. The average time of death in subzero weather from this method is not known. It is, however, known from direct observation that a caught marten will fight the trap until exhausted.

3. Fisher. <u>Martes pennanti</u>.

The twenty-two fisher used in this study, composed of fifteen males and seven females, were also obtained from commercial trappers in northern Ontario. These animals however were collected without the raw pelt weight being recorded. Therefore the regression equations for this species were drawn up using the pelted body weight instead of the total body weight.

This might give a more accurate expression than using the total body weight because of the removal of the subcutaneous fat, which varies considerably in amount from specimen to specimen.

TECHNIQUES

The weights of the carcasses and their pelts in the case of the mink were obtained immediately after death. The carcass of each animal was then placed in a Kraft paper bag for transportation to the laboratory, where they were deep frozen for one month. The marten and fisher were frozen as soon as possible and held in the freezer at the Southern Research Station at Maple, Ontario. Most of these animals were dissected at Maple; however, the remainder were flown to Vancouver in dry ice and dissected here. On removal from cold storage the animals were thawed for twelve hours. Dissection was then carried out as soon as possible to prevent excessive dehydration. A number of animals weighed before and after the freezing revealed that little change in weight occurred due to freezing and thawing.

The method of organ removal was described in detail in the preliminary report on the mink. Daniel (1957). However some of the more important details bear repetition. Each organ was removed and separated from associated tissues with care, to ensure uniformity of method, and placed momentarily on a sheet of absorbent paper to remove any excess of adherent blood or moisture. The heart weights were recorded after removal of the blood clots. In the case of the hearts, it was essential that the auricles be removed to facilitate the removal of the clotted blood. Thus the heart weights are in effect only the weights of the ventricles. It is pertinent to record that the auricles represent approximately one-fourth of the total heart weight. The dissection technique used for the heart could not eliminate the possibility of variable retention of blood in the numerous vessels and capillaries arising from hyperemic effects induced by the method of killing.

The livers were dipped in cold water to remove the surplus blood from the severed hepatic vein and then dried lightly with a paper towel. The recorded weights for the kidneys and adrenals are those from the left side of the animal only. However the weights of the thyroid and parathyroid gland are those of both pairs. The weights of the testes do not include the vasa deferentia.

CALCULATIONS

The exponential equations relating organ weight to body weight were calculated using the least squares regression method ~~of~~ outlined in Ezekiel (1930). The method for the Analysis of Covariance follows Snedecor (1946). It should be emphasized that the standard error of estimate used is the standard deviation from the regression line and is not the more usual and perhaps more meaningful standard deviation from the mean. The former method was used because it has been used in earlier work in the literature on this subject.

The two distinct populations of mink were treated as separate entities for purposes of calculation and interpretation. There appeared to be ample justification for separate statistical treatment of the data from the electrocuted and cyanided mink, based on the extensive literature of forensic medicine. Reese (1906); Smith (1928); Fulton (1955).

RESULTS AND DISCUSSION

1. Differences in organ weight between the cyanided and electrocuted mink

Previous workers, Hatai (1913), Addis and Gray (1950) and Brody (1945), have recorded organ weight-body weight interrelationships using the data from males and females as a single population. This was based on the assumption that for organs like the heart, lungs, liver and kidneys, there are no significant differences between the sexes. The above authors found, however, striking sex differences in the equations for such organs as the adrenals, thyroid, thymus and the male and female gonads.

This study was started accepting this assumption as valid and the regression equations were drawn up using the pooled data from both sexes. These equations and pertinent statistical values are given in Table 2.

Considering firstly the influence of method of sacrifice on the organ weights, it is apparent that when the sexes are treated as a single population, only the weights of the spleen and adrenal gland differ significantly when the two methods are compared.

TABLE 2 ORGAN WEIGHT RELATIVE TO BODY WEIGHT IN MINK

Data for males and females combined

Organ Weight = a Body Weight^{b}

Cyanide Killed Mink				Electrocuted Mink		
Regression Equation	Standard Error	Correlation coefficient		Regression Equation	Standard Error	Correlation coefficient
$SW = 0.011\ BW^{.76}$	20%,-17%	.67	Spleen	$SW = 0.354\ BW^{.28}$	67%,-40%	.20
$KW = 0.019\ BW^{.73}$	17%,-14%	.87	Kidney	$KW = 0.012\ BW^{.79}$	16%,-14%	.94
$AW = 0.082\ BW^{.54}$	68%,-40%	.41	Adrenal**	$AW = 0.002\ BW^{1.1}$	56%,-36%	.66
$LW = 0.244\ BW^{.73}$	13%,-11%	.89	Liver	$LW = 0.079\ BW^{.89}$	21%,-11%	.98
$LW = 0.166\ BW^{.63}$	17%,-14%	.90	Lungs	$LW = 0.121\ BW^{.66}$	16%,-14%	.85
$HW = 0.022\ BW^{.78}$	26%,-21%	.88	Heart	$HW = 0.022\ BW^{.78}$	14%,-8%	.95
$SW = 0.143\ BW^{.49}$	19%,-16%	.75	Stomach	$SW = 0.127\ BW^{.50}$	18%,-15%	.77

** values for adrenal gland in centigrams

TABLE 3 ORGAN WEIGHT RELATIVE TO BODY WEIGHT IN ELECTROCUTED MINK

Data for males and females separate

Organ weight = a Body weight^b

Female mink				Male mink		
Regression Equation	Standard Error	Coefficient correlation		Regression Equation	Standard Error	Coefficient correlation
$SW = 0.0023\ BW^{1.0}$	40%,-28%	.36	Spleen	$SW = 0.074\ BW^{.52}$	60%,-37%	.34
$KW = 0.00001\ BW^{1.9}$	23%,-17%	.85	Kidney	$KW = 0.271\ BW^{.37}$	19%,-16%	.77
$AW = 0.0075\ BW^{1.2}$	70%,-42%	.30	Adrenal**	$AW = 1.57\ BW^{.48}$	50%,-33%	.26
$LW = 0.0001\ BW^{1.9}$	20%,-17%	.83	Liver	$LW = 0.929\ BW^{.56}$	12%,-11%	.60
$LW = 0.017\ BW^{.95}$	13%,-12%	.74	Lungs	$LW = 0.622\ BW^{.44}$	16%,-14%	.68
$HW = 0.09\ BW^{.56}$	24%,-12%	.94	Heart	$HW = 0.013\ BW^{.85}$	9%,-8%	.91
$SW = 0.011\ BW^{.87}$	15%,-13%	.80	Stomach	$SW = 0.118\ BW^{.52}$	19%,-16%	.50

** Values for adrenal glands are in milligrams

TABLE 4 ORGAN WEIGHT RELATIVE TO BODY WEIGHT IN CYANIDE KILLED MINK

Data for males and females separate

Organ weight = a Body weight^{b}

Female Mink				Male Mink		
Regression Equation	Standard Error	Coefficient correlation		Regression Equation	Standard Error	Coefficient correlation
$SW = 0.032\ BW^{.60}$	32%,-27%	.33	Spleen	$SW = 0.139\ BW^{.42}$	32%,-24%	.24
$KW = 0.222\ BW^{.37}$	11%,-9%	.68	Kidney	$KW = 0.049\ BW^{.61}$	15%,-13%	.55
$AW = 5.85\ BW^{.24}$	65%,-38%	.35	Adrenal**	$AW = 9.80\ BW^{.22}$	58%,-35%	.41
$LW = 1.54\ BW^{.46}$	6%,-4%	.77	Liver	$LW = 1.30\ BW^{.51}$	16%,-14%	.67
$LW = 0.74\ BW^{.40}$	18%,-15%	.64	Lungs	$LW = 4.67\ BW^{.18}$	37%,-28%	.57
$HW = 0.187\ BW^{.46}$	13%,-12%	.80	Heart	$HW = 0.206\ BW^{.48}$	13%,-11%	.84
$SW = 3.58\ BW^{.03}$	19%,-16%	.51	Stomach	$SW = 4.09\ BW^{.06}$	18%,-16%	.40

**- Values for adrenal glands are in milligrams

However, when the electrocuted and cyanided data were plotted on log-log paper, it became apparent that in the electrocuted series there were two distinct phases in the curve of most of the organs. These phases, unlike the three phases in the adrenal gland of the rat, Hatai (1913), or the three phases in the testes and ovaries in the rat, Addis and Gray (1950), represent distinctly separate phases in the growth curves for the males and females. This meant that for the electrocuted mink, the computed equations representing the pooled data, Table 2, were worthless and did not represent the line of best fit for each distinct phase in the curve of points. Following this finding, all the data was recomputed and separate regression equations were drawn up for each sex and for each method of sacrifice. These results are presented in Tables 3 and 4. The regression lines fitted to the data by the method of least squares are shown for each organ in Figures 1-7.

A study of Table 4 shows that the exponent values for the males and females in the cyanide killed mink for the organs studied are very similar. The significance of these differences for each organ was tested using the "t" test comparing the two values of "b", the slopes, in the regression lines of the two series. The result was as expected. None of the differences between the two series was found to be statistically significant. Thus for the cyanide killed mink, the assumptions of Hatai and Addis and Gray seem to be borne out for the organs studied. The regression equations in Table 2 for the cyanided mink are therefore still valid even though the data has been pooled.

However, from Table 3, the equations for the electrocuted mink show striking sex differences for most of the organs studied.

52-416a

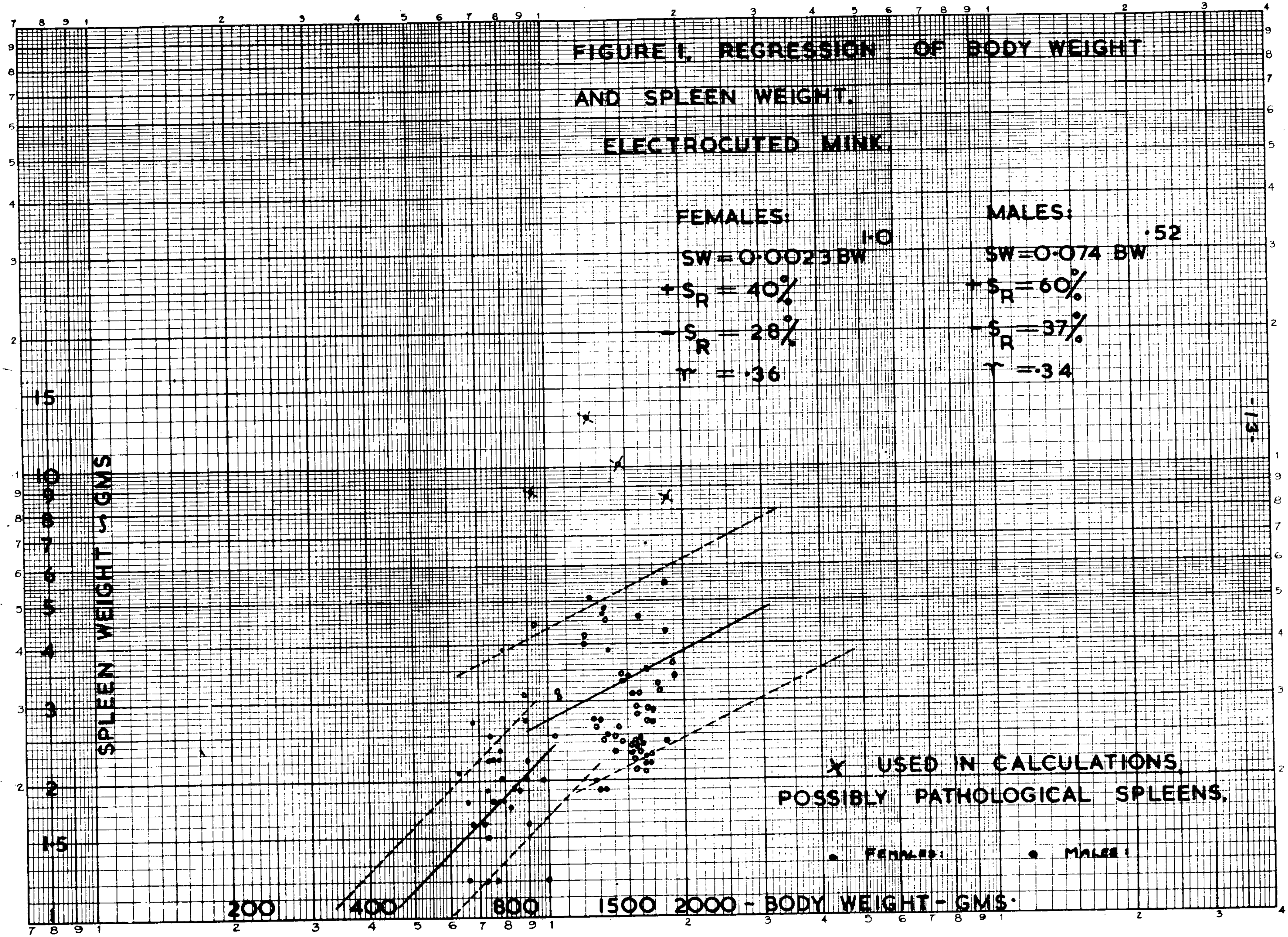


FIGURE I. REGRESSION OF BODY WEIGHT
AND SPLEEN WEIGHT.
ELECTROCUTED MINK.
FEMALES:
SW=0·0023 BW 1·0
+S_R = 40%
−S_R = 28%
r = ·36
MALES:
SW=0·074 BW ·52
+S_R = 60%
−S_R = 37%
r = ·34
X USED IN CALCULATIONS.
POSSIBLY PATHOLOGICAL SPLEENS.
FEMALES:
MALES:
SPLEEN WEIGHT – GMS
200 400 800 1500 2000 – BODY WEIGHT – GMS.

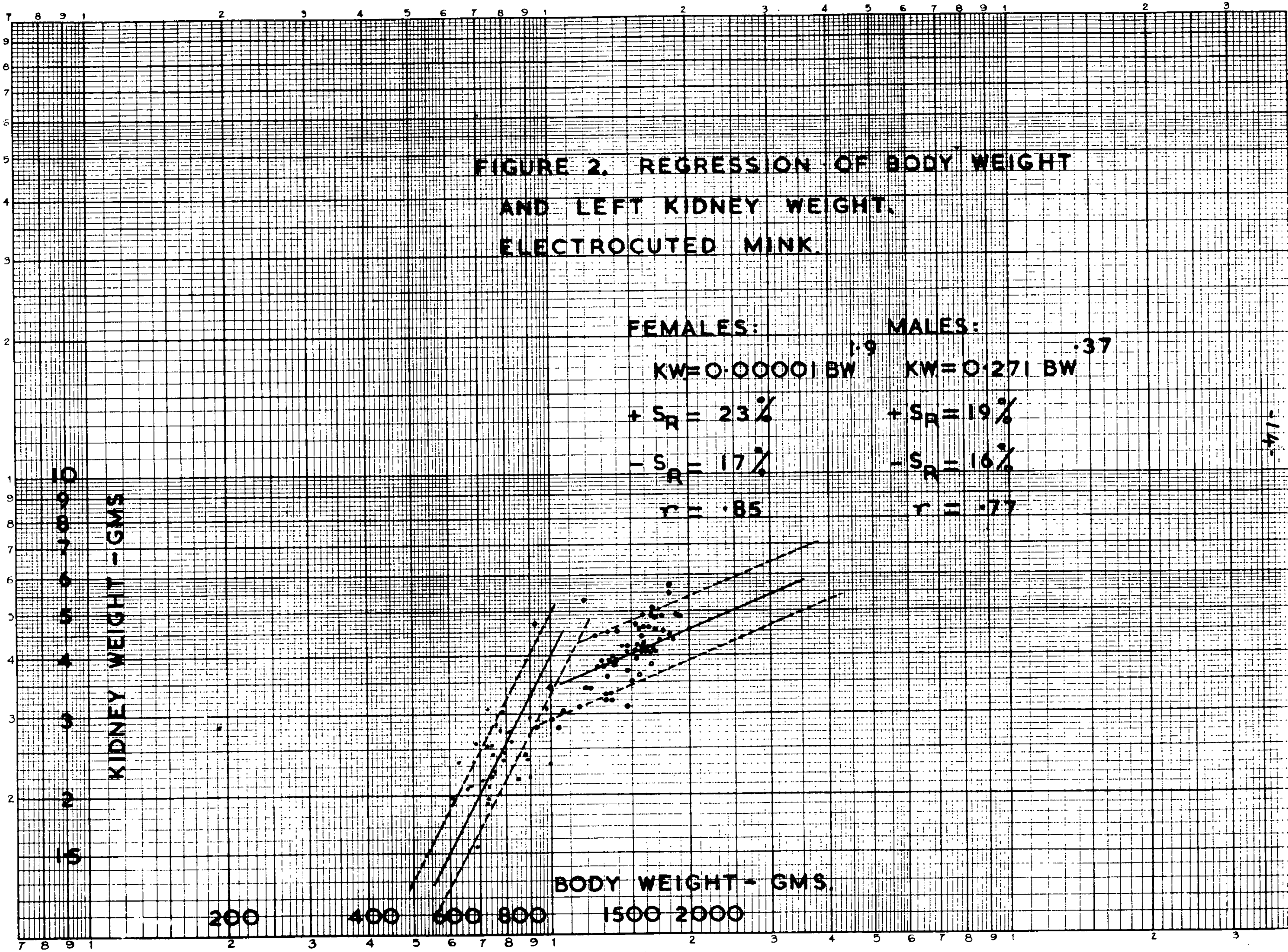


FIGURE 2. REGRESSION OF BODY WEIGHT
AND LEFT KIDNEY WEIGHT.
ELECTROCUTED MINK.
FEMALES:
$KW = 0{\cdot}00001\ BW^{1{\cdot}9}$
$+S_R = 23\%$
$-S_R = 17\%$
$r = {\cdot}85$
MALES:
$KW = 0{\cdot}271\ BW^{{\cdot}37}$
$+S_R = 19\%$
$-S_R = 16\%$
$r = {\cdot}77$
KIDNEY WEIGHT - GMS
10
9
8
7
6
5
4
3
2
1.5
BODY WEIGHT - GMS.
200
400
600
800
1500
2000

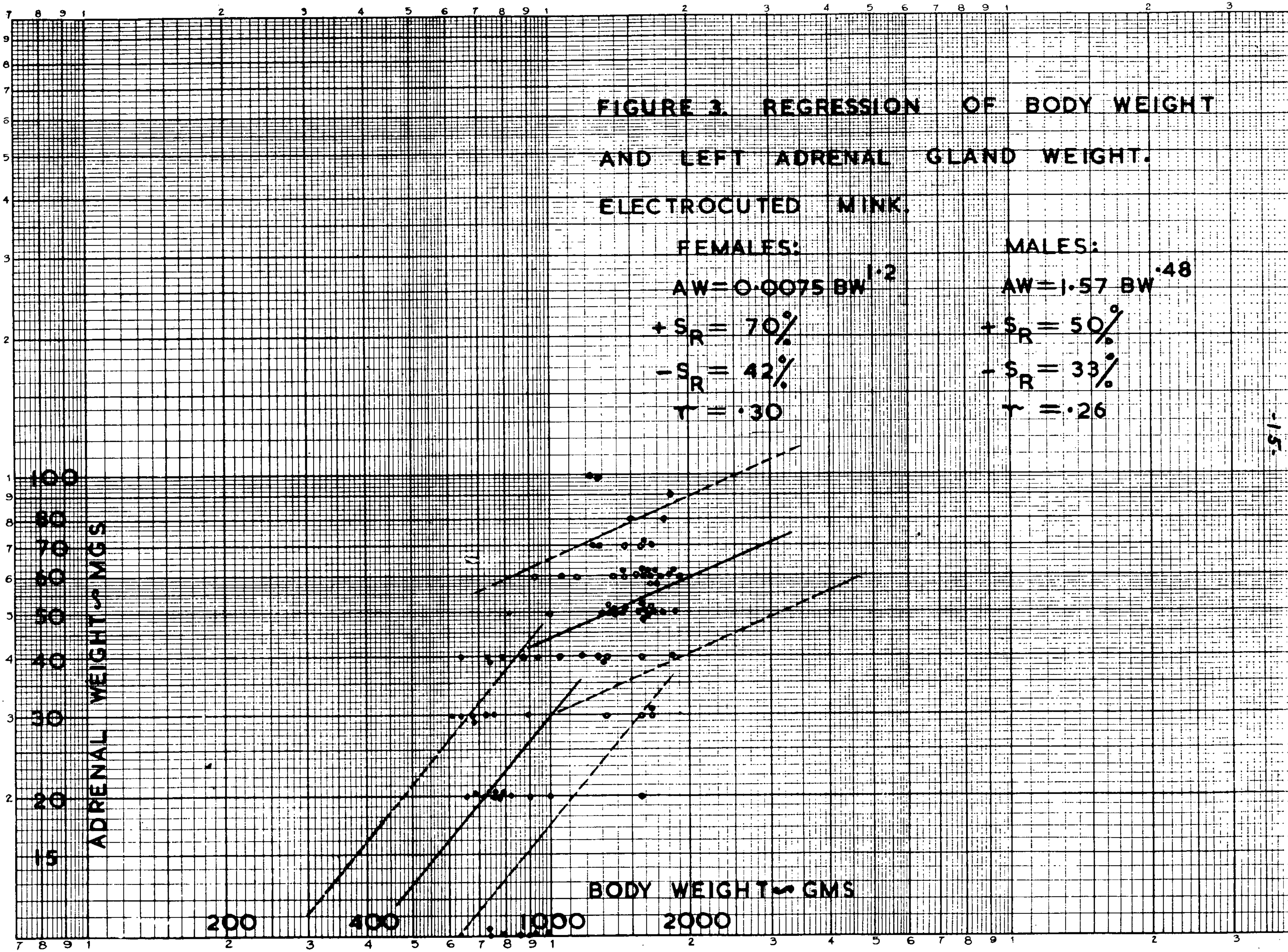


FIGURE 3. REGRESSION OF BODY WEIGHT AND LEFT ADRENAL GLAND WEIGHT. ELECTROCUTED MINK.

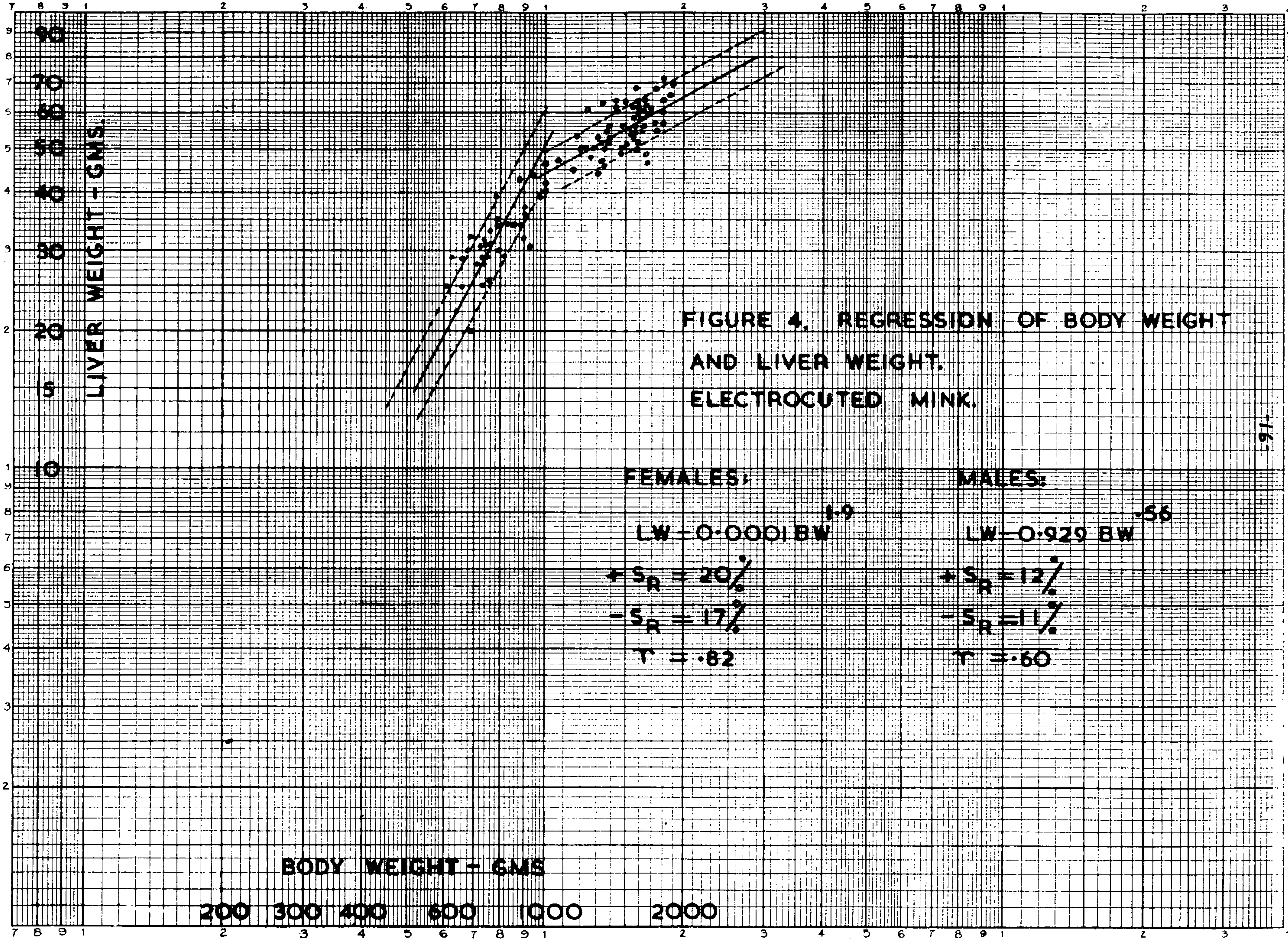


FIGURE 4. REGRESSION OF BODY WEIGHT AND LIVER WEIGHT. ELECTROCUTED MINK.

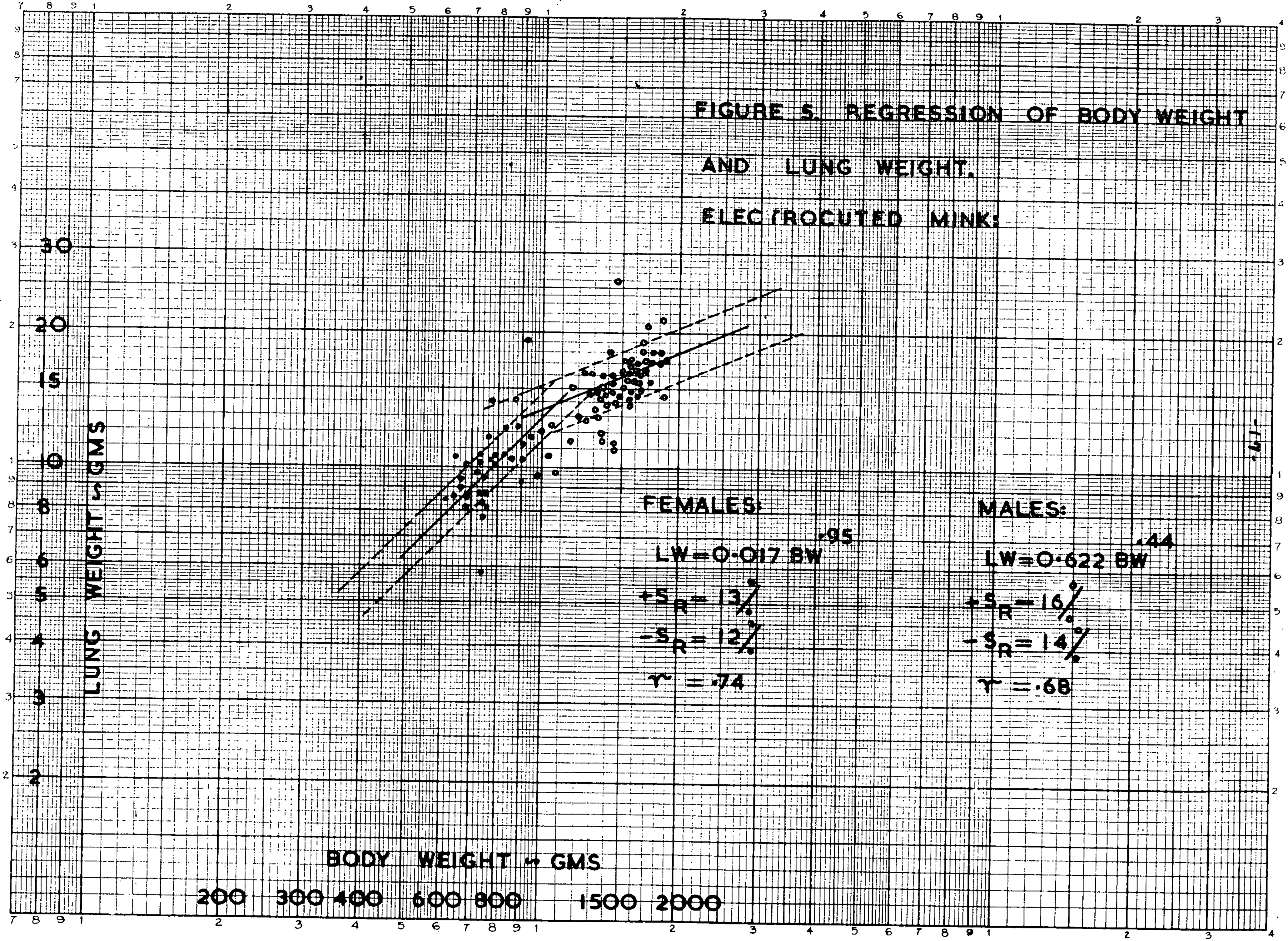


FIGURE 5. REGRESSION OF BODY WEIGHT AND LUNG WEIGHT.
ELECTROCUTED MINK:

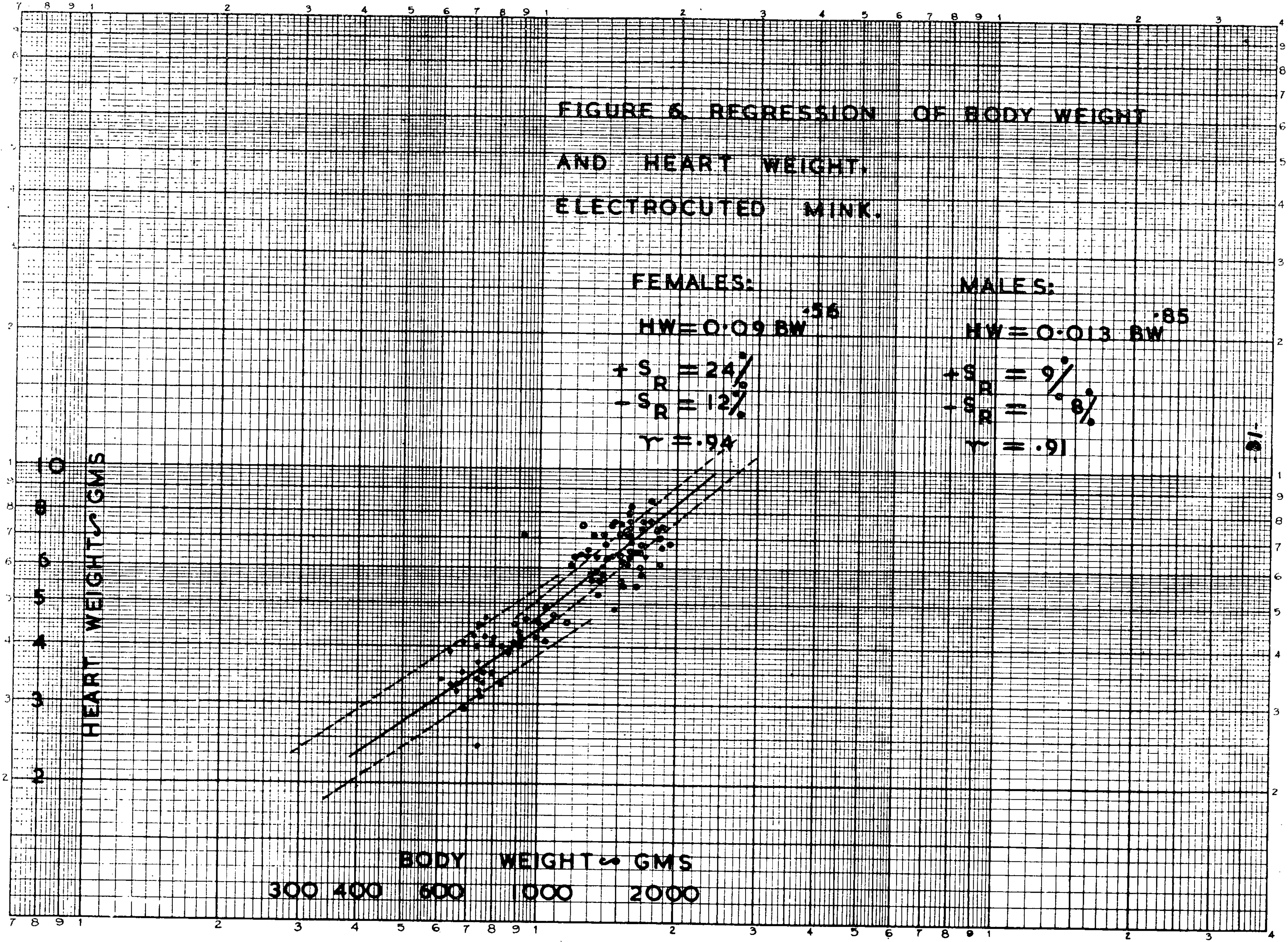


FIGURE 6. REGRESSION OF BODY WEIGHT
AND HEART WEIGHT.
ELECTROCUTED MINK.
FEMALES:
HW = 0·09 BW·56
+SR = 24%
-SR = 12%
r = ·94
MALES:
HW = 0·013 BW·85
+SR = 9%
-SR = 8%
r = ·91
HEART WEIGHT ~ GMS
10
8
6
5
4
3
2
BODY WEIGHT ~ GMS
300 400 600 1000 2000

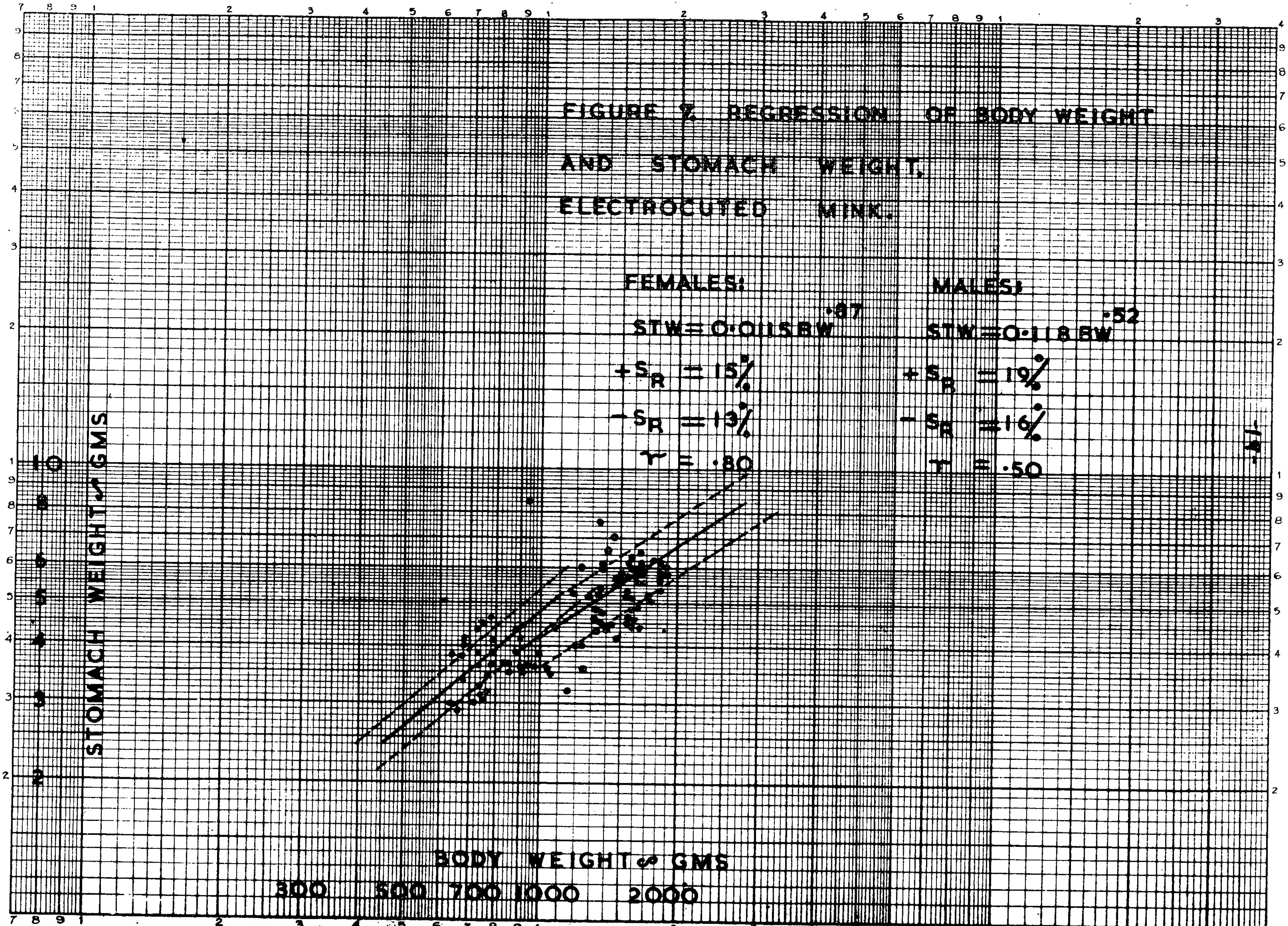


FIGURE 7. REGRESSION OF BODY WEIGHT
AND STOMACH WEIGHT.
ELECTROCUTED MINK.
FEMALES:
STW = 0·0115 BW·87
+SR = 15%
−SR = 13%
r = ·80
MALES:
STW = 0·118 BW·52
+SR = 19%
−SR = 16%
r = ·50
STOMACH WEIGHT ∽ GMS
10
8
6
5
4
3
2
BODY WEIGHT ∽ GMS
300
500
700
1000
2000

See Figures 1-7. It can be seen that the values for the exponents for the females are in some cases 3-4 times the corresponding values for the males and for their cyanide counterparts. These sex differences were tested for significance and it was found that the kidney, liver, and adrenal were highly significant. ($p \simeq 0.010$) while the spleen and lungs were significant ($p \simeq 0.050$). The exponents for the heart and stomach were not significant, even at the 5% level. It should be emphasized that the above test only compares the significance of the slopes of the regression lines. A far more refined method for testing the significance of the slope and the y-intercept at the same time is the Analysis of Covariance, Snedecor, (1946). The regression equations of the female electrocuted mink were compared with the female cyanide mink using this refined statistical technique. The results were as expected. The exponents and y-intercepts of the female electrocuted mink were highly significantly different for the kidney, liver and adrenal, ($p = 0.010$). Those for the spleen and lungs were significant at the 5% level, ($p = 0.050$). Those for the heart were not significant at all.

It appears from these findings that there may be significantly more engorgement in the various organs of the female electrocuted mink, than in the larger organs of the males of the same series.

It is well documented in the many texts of forensic medicine that the visceral organs of man and other animals become greatly engorged with blood, both in electrocution and as the result of death by hydrogen cyanide gas. Reese (1906), Smith (1928), Fulton (1955).

According to J. J. Reese, in the text, Medical Jurisprudence and Toxicology, (1906) in the post mortem examinations of electrocuted men, "The brain and cerebral membranes suffer most, ... , the lungs are congested and injured, the stomach and intestines, liver and spleen are also much congested with blood. The heart does not seem to show any special alteration."

Sydney Smith, in Forensic Medicine, (1928), states that the post mortem signs of electrocution are

"The trachea is much congested, the lungs deeply engorged and the great vessels full of fluid blood. The abdominal viscera is also deeply engorged with blood."

The post mortem signs of death by hydrogen cyanide gas are very similar to those recorded above. In humans there is congestion of the cerebral vessels, the lungs and liver and also the mucous membranes of the stomach, e specially about the cardiac extremity, (Reese, (1906). According to S. Smith (1928), a feature of d eath by cyanide asphyxia is the dark blood in the venous side of the circulation. This is due to the impeded oxygenation of the tissues by the cyanide and also to the presence of cyanomethaemoglobin.

As far as could be determined, death by electrocution was almost instantaneous, within 5-10 seconds. With the mink, as in the rabbits used by Urquhart, (1927), on application of the current the animals went into a generalized contraction, which was maintained for the duration of the current. When the current was broken, a few convulsions were noted and then complete muscular relaxation occurred.

There are many views as to what actually causes d eath when an electric current passes through an animal. However, the most generally accepted theory is that there are three possible causes of death, Jellinck, (1913), MacWilliam, (1915) and Urquhart, (1927).

1. Arrest of respiration from paralysis of the respiratory centre while the heart goes on beating. Death here is due to asphyxia.

2. Overthrow of normal heart action by sudden development of ventricular fibrillation replacing the normal systole.

3. A combination of the two.

The relative incidence of these types of death depends on the location of the application of the current, and on the strength and pressure of that current. MacWilliam, (1915). According to Urquhart, (1927 and 1951), when a current of high voltage traverses the animal from head to tail, the death is caused by ventricular fibrillation in 45% of the cases. However, he found that with high voltages, over 500 volts, the brain and spinal cord were more often affected, while with lower voltages the heart was the site most often affected.

It was first reported by Prevost and Battelli that there is a decided difference in the effect of similar electric currents on animals of different species, and indeed on animals of the same species, Urquhart, (1927). This seems to apply to the mink, where the females, being the lighter animals, show greater effects from the current, than do the heavier males. It is possible that the females react more because per gram of body weight the females get almost twice the current that the males receive. This would, however, tend to lower the exponent values for the females and not raise them as was the case.

In humans the females are more susceptible to electric current, because their skin with less hair and more sweat glands offers less resistance than the tough skin of the male. Jellinck, (1913). This would of course have no application to the female mink. However, the reason for this differential engorgement in the female mink lies not in the fact that the females are lighter but in the fact, found by Jellinck (1913), that when animals are well wetted down, the larger the surface area, the more current flows over the surface of the animal, and less flows inside the animal, to do damage to the respiratory centre or the heart. With this theory the smaller female mink would receive much more current than the males. This, however, does not explain why the smallest females, 500-700 gms, do not react more strongly than the larger females.

In order to explore this apparent difference in response to lethal agencies histological sections were prepared in the following way. Four adult female mink were sacrificed, two by each method. The organs were quickly removed and preserved in Bouin's solution. The tissues were then cut at seven microns and stained with haematoxylineosin and mounted in the normal way. Examination of these two sets of histological sections show that the capillaries in both sets are swollen with blood.

The adrenal glands

In the electrocuted series the adrenal cortex is definitely more vasculated than the same area in the cyanided mink, Photomicrographs 1 and 2. From the photomicrograph it can be seen that the vascularized parts of the cortex are the zona fasciculata and the zona reticularis. It is interesting to note that the medulla of the cyanide adrenals is more vascularized than the medulla of the other series. This difference is not understood.

The spleen

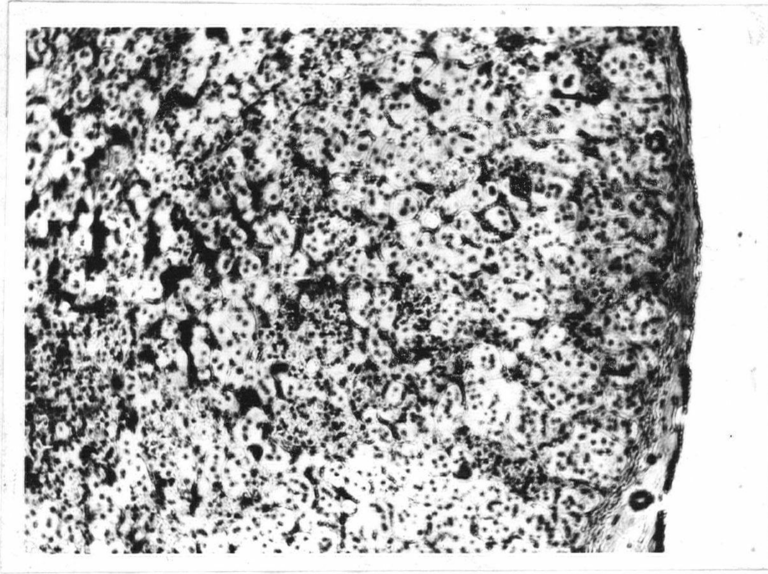
From photomicrographs 3 and 4 it can be seen clearly that the red pulp and sinusoids of the spleen from the electrocuted animals are conspicuously more vasculatized than the corresponding areas in the cyanide series. The arteries and veins in the trabeculae of both series appear to be equally engorged.

The liver, lungs and kidney

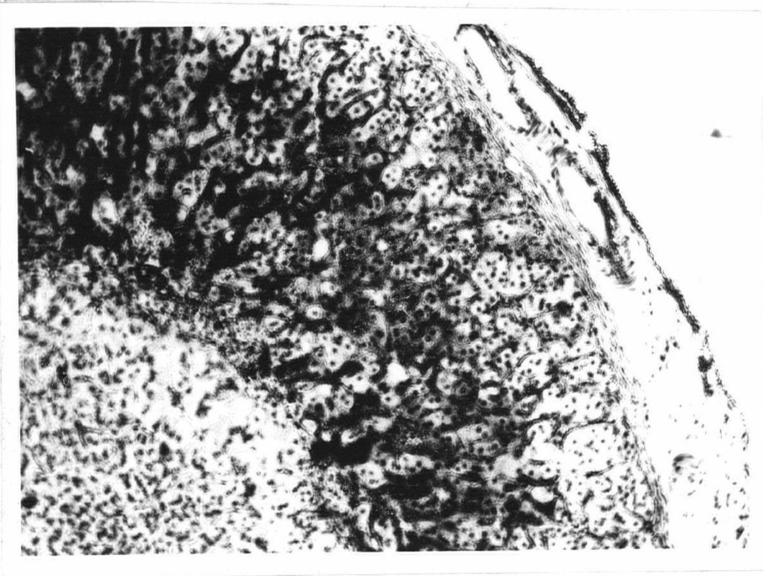
From photomicrographs 5-10 it can be seen that these organs are engorged by both methods of sacrifice. However, because of their large and complicated nature, a small increase in vasculatization which would be obvious in such small organs as the spleen and adrenals, would remain undetected. The sinusoids of the liver and the medulla of the kidney in the electrocuted series appear more vasculatized however no means could be discovered to permit quantitative expression of the degree of vasculatization.

From Figures 1-7, it can be seen that the curves of the lighter male mink follow closely those of the female mink. This indicates that the differential response to electrocution is not dependent on the sex but on the body weight and hence relatively larger surface area of the smaller animals.

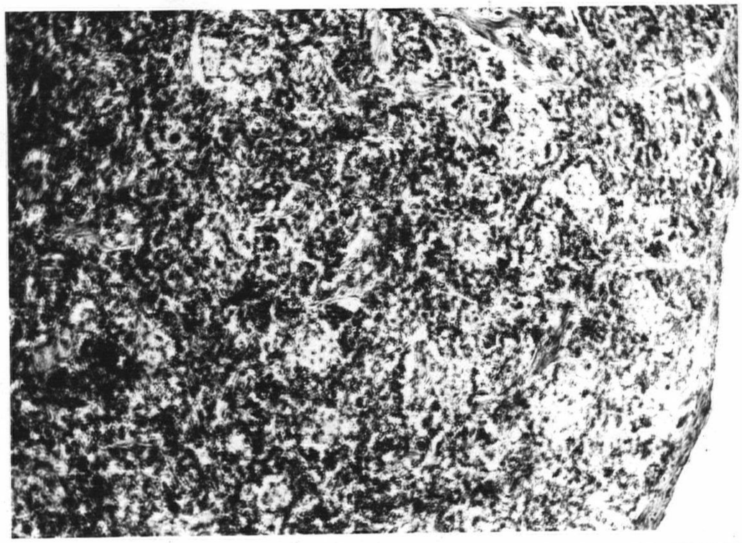
It is appreciated that further work is needed on the exact changes which occur in various tissues when different lethal agents are used. It is hoped that other workers will try electrocuting both males and females of the same species by varying the amount of current and noting the histological changes. It would be interesting to find out if the same results occur in female mink when the current is halved.



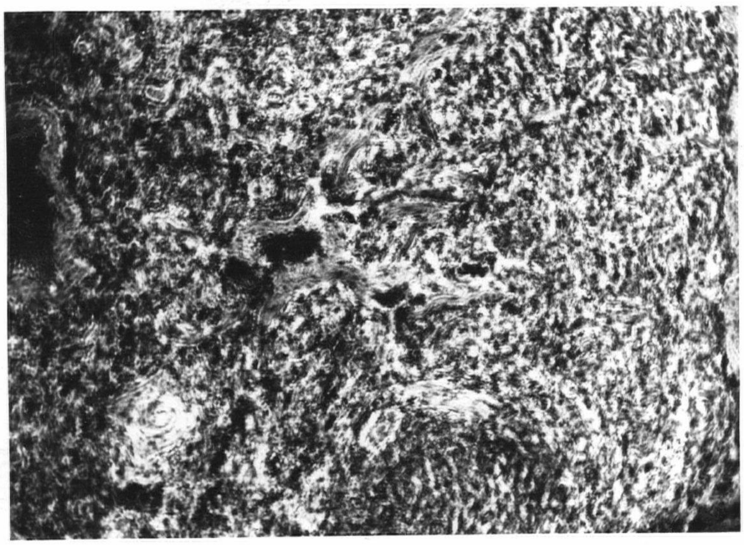
Photomicrograph I. Adrenal gland, cyanided female mink.
Exposure 2 seconds. High contrast green filter used. Magnification 34.



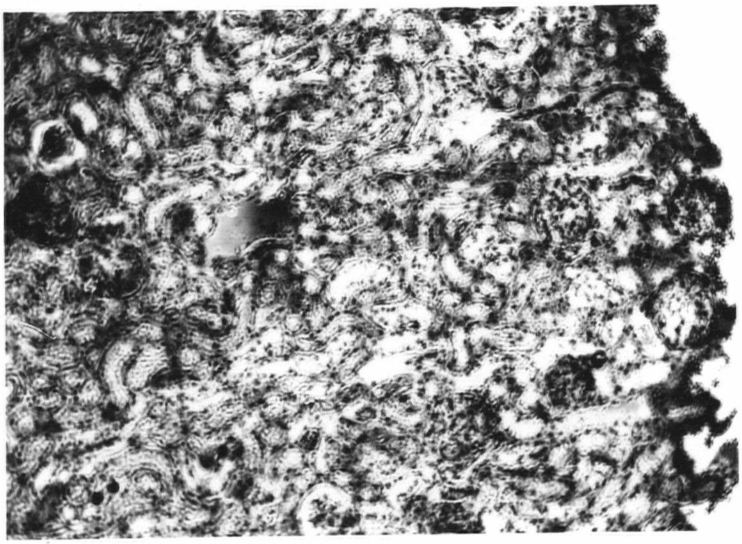
Photomicrograph 2. Adrenal gland, electrocuted female mink.
Exposure 2 seconds. High contrast green filter used. Magnification 34.



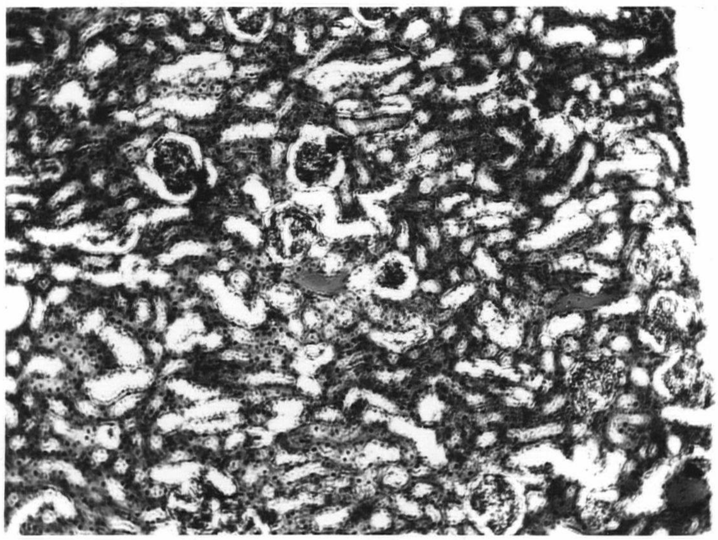
Photomicrograph 3. Spleen. Cyanided female mink.
Exposure 2 seconds. High contrast green filter used. Magnification 34.



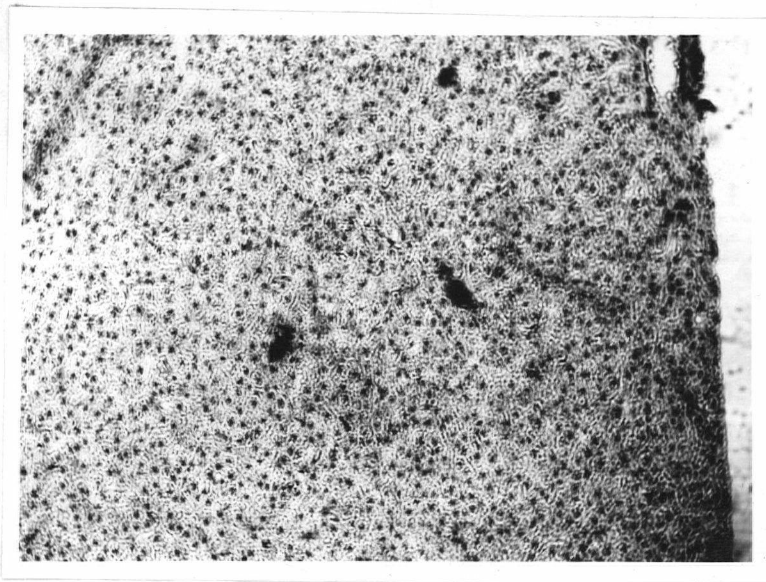
Photomicrograph 4. Spleen. Electrocuted female mink.
Exposure 2 seconds. High contrast green filter used. Magnification 34.



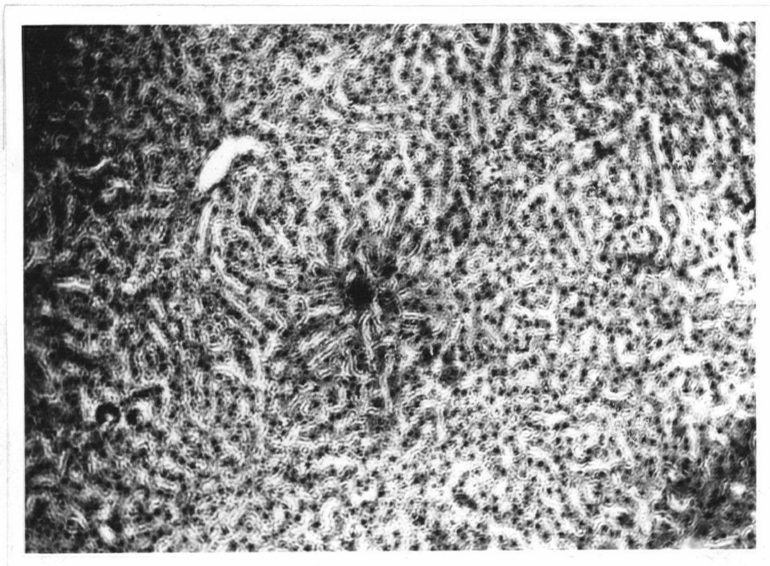
Photomicrograph 5. Kidney. Cyanided female mink.
Exposure 2 seconds. High contrast green filter used. Magnification 34.



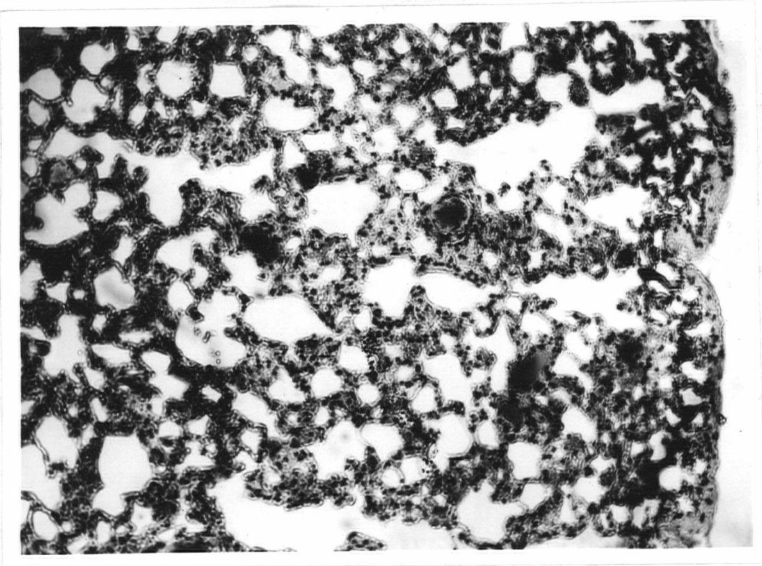
Photomicrograph 6. Kidney. Electrocuted female mink.
Exposure 2 seconds. High contrast green filter used. Magnification 34.



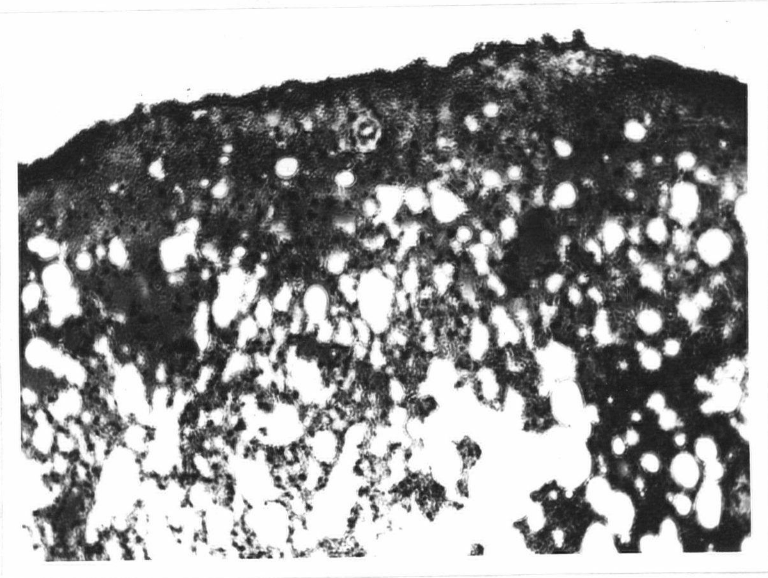
Photomicrograph 7. Liver. Cyanided female mink.
Exposure 2 seconds. High contrast green filter used. Magnification 34.



Photomicrograph 8. Liver. Electrocuted female mink.
Exposure 2 seconds. High contrast green filter used. Magnification 34.



Photomicrograph 9. Lung. Cyanided female mink.
Exposure 2 seconds. High contrast green filter used. Magnification 34.



Photomicrograph 10. Lung. Electrocuted female mink.
Exposure 2 seconds. High contrast green filter used. Magnification 34.

Results and Discussion

2. Prediction table of organ weights for electrocuted mink

The prediction table of organ weights was drawn up using the data from the electrocuted mink because this method of sacrifice is the one most commonly used to-day, hence the table would have more value than one based on mink killed by any other method.

However, it should be noted that this table, in Appendix I, is only of real value for those organs where the correlation is reasonably high. For this reason the values for the spleen and the adrenal gland are unreliable. These two organs are, however, included in the prediction table for the sake of completeness, but in the opinion of the writer they may have little value.

When consulting the table for organ weights at any given body weight, the calculated allowable error should be kept in mind. For details of the standard error and correlation coefficient see Table 3.

The writer realizes the limitations of this table and for that matter also the tables given in Brody (1945). If, however, these limitations are not overlooked, it is hoped that the predictions are of some value.

This prediction table, Appendix I, is based on the regression equations where the sexes were calculated separately, Table 3, and not on the equations where the sexes were combined as in Table 2.

The predicted values for the kidney and adrenal gland refer to those from the left side of the animal only. It was found that the right kidney was 4% heavier than the left one. This was taken into account in the special comparison table. No difference was detected between the weights of the left and right adrenal gland.

3. The Marten and Fisher

(a) Concerning "normal" organ weights

The marten and fisher used in this study were caught, as has been mentioned previously, in steel traps by commercial trappers in northern Ontario. One of the objects of this study was to collect a series of "normal" organ weights for these three species. However, there may be reason to doubt if there is such a thing as a "normal" organ.

It is clear that these two species were under conditions of extreme stress before they died in the traps. The time taken to die in these traps is not known, but it is assumed that the more healthy animals survived for several hours in spite of subzero weather. Thus it seems that the stressing stimuli, in this case, rage, fear, exhaustion from fighting the trap, and cold, were sufficient to elicit an adrenocortical response. This is the now famous "stress adaptation syndrome" of Selye, (1946).

If this was the case, the values obtained for the adrenals would be heavier than normal due to cortical hypertrophy. This increase in adrenal weights due to prolonged stress has been found to be due to an increase in cortical tissue, particularly in the zona fasciculata. Christian, (1955). The adrenal medulla, however, does not contribute to this increase in weight in rats as found by Rogers and Richter, (1948).

However, according to Selye, (1946), the stress must be of sufficient intensity and over a long period of time before there is any actual increase in the adrenal cortical tissue. For stress of shorter duration there must be significant changes in the amount of fluid, particularly blood, in such organs as the spleen, adrenal and liver. From the histological sections taken of the visceral organs of mink, it has already been shown that even when the animal died within 20-30 seconds, there is significant differential engorgement of these organs with blood.

It has been shown by Chitty (1955), that when the stressing stimuli are sufficiently strong and continued for a long period of time, the weights of the adrenals, spleen and liver go up. He found also that the weight of the thymus gland went down. This was also recorded by Christian (1957), who said that the weights of the thymus gland were related in a roughly inverse fashion to the weights of the adrenals. In this study not enough data on this gland was recorded for comparative purposes. Clark, (1953), also working with the vole, Microtus agrestis, found a similar rise in the weights of the spleen and adrenal with prolonged stress. This splenic hypertrophy was confirmed in voles by Dawson (1956).

Thus it is appreciated that the weights recorded for the marten and fisher for certain of the organs are by no means "normal". However, as long as this is kept in mind, the writer believes that valid comparisons can be made between these three species and with the predicted values given by Brody (1946), computed from a large number of mammals.

(b) Regression equations

The regression equations for the marten are given in Table 5, and the data is presented graphically in Figures 8-15. For the fisher the equations and other pertinent statistical data are presented in Table 6. The same results are presented graphically in Figures 16-23.

TABLE 5 ORGAN WEIGHT RELATIVE TO BODY WEIGHT IN STEEL TRAPPED MARTEN

Males and females combined

$$Y = aX^b$$

	Regression Equation	Standard Error	Coefficient of Correlation
Spleen*	$SW = 0.3429\ BW^{.53}$	18%,-16%	.47
Kidney	$KW = 0.0160\ BW^{.77}$	20%,-16%	.70
Adrenal**	$AW = 9.997\ BW^{.27}$	52%,-34%	.24
Liver	$LW = 0.1748\ BW^{.73}$	16%,-14%	.96
Lungs	$LW = 0.0520\ BW^{.82}$	15%,-12%	.62
Heart	$HW = 0.0368\ BW^{.77}$	11%,-9%	.84
Testes***	$TW = 0.0303\ BW^{1.30}$	22%,-18%	.76
Thyroid & parathyroid xxxx	$ThW = 0.1294\ BW^{.93}$	78%,-43%	.34

* Values for spleen in decigrams
** Values for adrenal gland in milligrams
*** Values for testes in milligrams
**** Values for thyroid and parathyroid glands in milligrams

TABLE 6 ORGAN WEIGHT RELATIVE TO PELTED BODY WEIGHT IN STEEL TRAPPED FISHER

Date for males and females combined

$$Y = aX^b$$

	Regression Equation	Standard Error	Coefficient of Correlation
Spleen	$SW = 0.0018\ BW^{1.00}$	24%, -20%	.51
Kidney	$KW = 0.0028\ BW^{1.03}$	14%, -12%	.86
Adrenal*	$AW = 0.4017\ BW^{.82}$	50%, -35%	.51
Liver	$LW = 0.0163\ BW^{1.12}$	25%, -18%	.85
Lungs	$LW = 0.0814\ BW^{.34}$	20%, -16%	.68
Heart	$HW = 0.0763\ BW^{.72}$	9%, -6%	.92
Testes	$TW = 0.0036\ BW^{.80}$	50%, -35%	.55
Thyroid** & parathyroid	$ThW = 1.91\ BW^{.60}$	40%, -25%	.54

* Values for adrenal gland in milligrams

** Values for thyroid and parathyroid glands in milligrams

For these two species, two additional organs have been studied in addition to those studied for the mink. These are the thyroid and parathyroid glands and the testes without the vasa deferentia. The thyroids with their closely associated parathyroids were recorded because both Brody (1945) and Addis and Gray (1950) have data for these glands for a number of species, which would make comparison easier. According to Christian (1955) there is no detectable change in the weight of the thyroids in animals which have undergone prolonged stress.

Due to insufficient data the sexes were not separated when computing the regression equations for the different organs. However the equations for the fisher were computed using the pelted body weight instead of the usual total body weight. This was done because of lack of data on the raw pelt weights of this species. From the data of the mink and marten, the average raw pelt weight is approximately 20% of the total body weight or 40% of the pelted body weight. Using this figure of 40%, which admittedly is only approximate, because the raw pelt weights of the larger fisher may not follow closely those of the ranch mink, comparisons can be made.

(c) <u>Comparison of organ weights of the marten, mink and fisher</u>

In Table 7, the mink and marten at a body weight of 700 gms are compared with the predicted organ weights for a 700 gm animal from the table in Brody (op. cit.). This table was computed using the data from a large number of terrestrial mammals.

TABLE 7 Species Comparison Table No. 1. All at 700 gms.

Species	* Adrenal	** Thyroid	Liver	Lungs	Heart	*** Kidneys	Spleen
Mink	40 mgs	-	26 gms	9.0 gms	3.5 gms	4.1 gms	1.6 gms
Marten	120 gms	60 mgs	21 gms	11.2 gms	5.7 gms	4.9 gms	1.1 gms
Brody's predict-ions	206 mgs	93 mgs	24 gms	7.9 gms	4.1 gms	5.4 gms	-

* The weights for the left adrenal were doubled, assuming that the two adrenals are of approximately the same weight.

** The weights of the thyroid gland include both the thyroids and the parathyroids.

*** In the mink and marten it was found that the right kidney was 4% heavier than the left kidney. Addis and Gray found a 3% difference in the white rat. Thus the total weight for both kidneys was computed taking this difference into account.

The mink used for this table were 700 gm electrocuted mink.

From this table it can be seen that:-

(1) The mink has a relatively smaller heart and lungs than both the marten and the values predicted by Brody. This was expected because the heart weight of any animal is related to the exercise level of the species. It has been found by Brody (1945) that an aquatic or semi-aquatic species invariably has a smaller heart than terrestrial animals because their weight is counterpoised by the water that they displace. It is appreciated that the mink used were ranch mink and not wild mink. However, it seems probable that this condition would also be found in the wild mink.

(2) The mink also has relatively smaller lungs than the marten but smaller than those of Brody's animal. This follows the theory that a

52-416a
Litho'd by Best Mimeograph Co. Ltd., Vancouver, B.C.

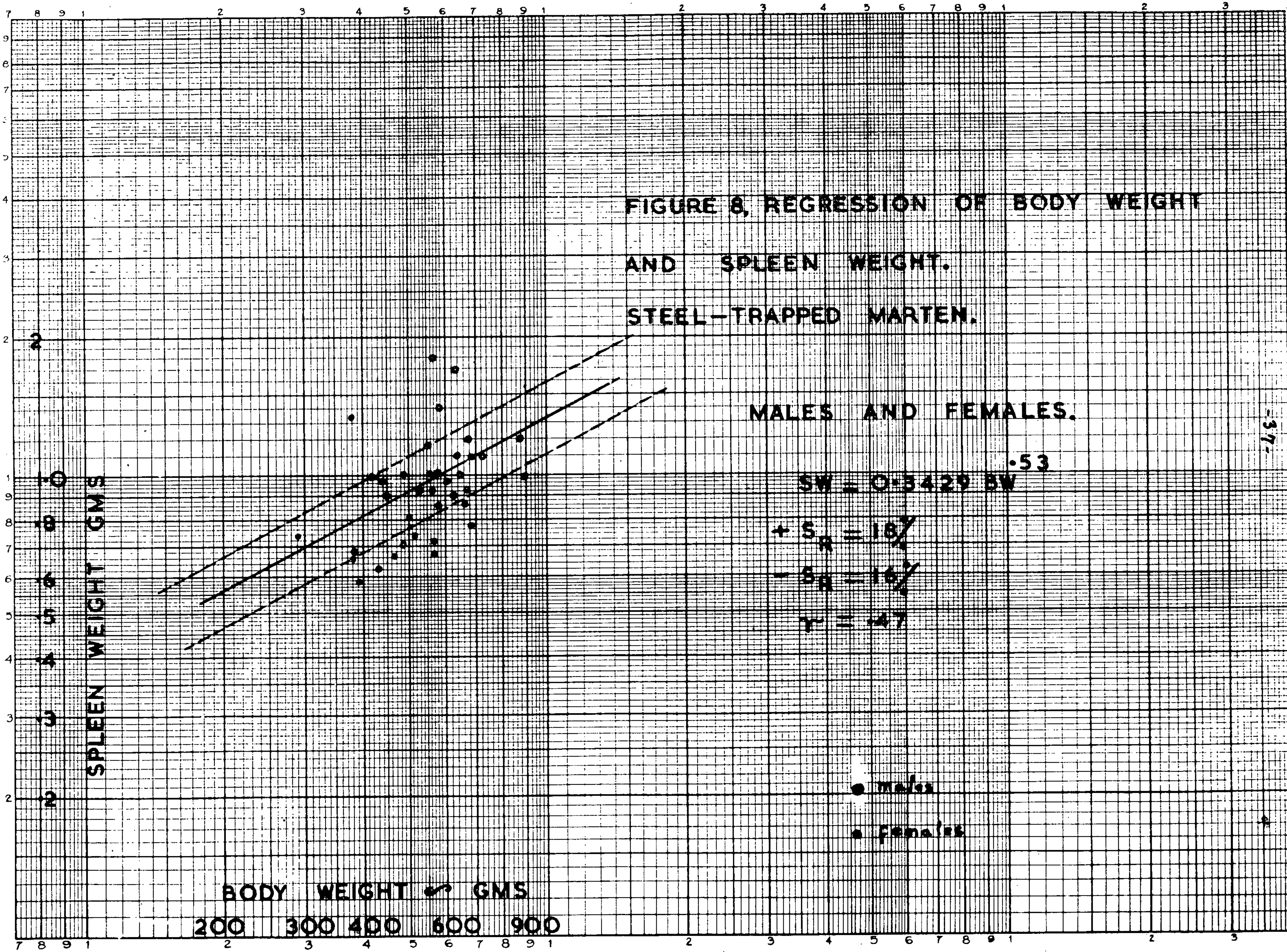
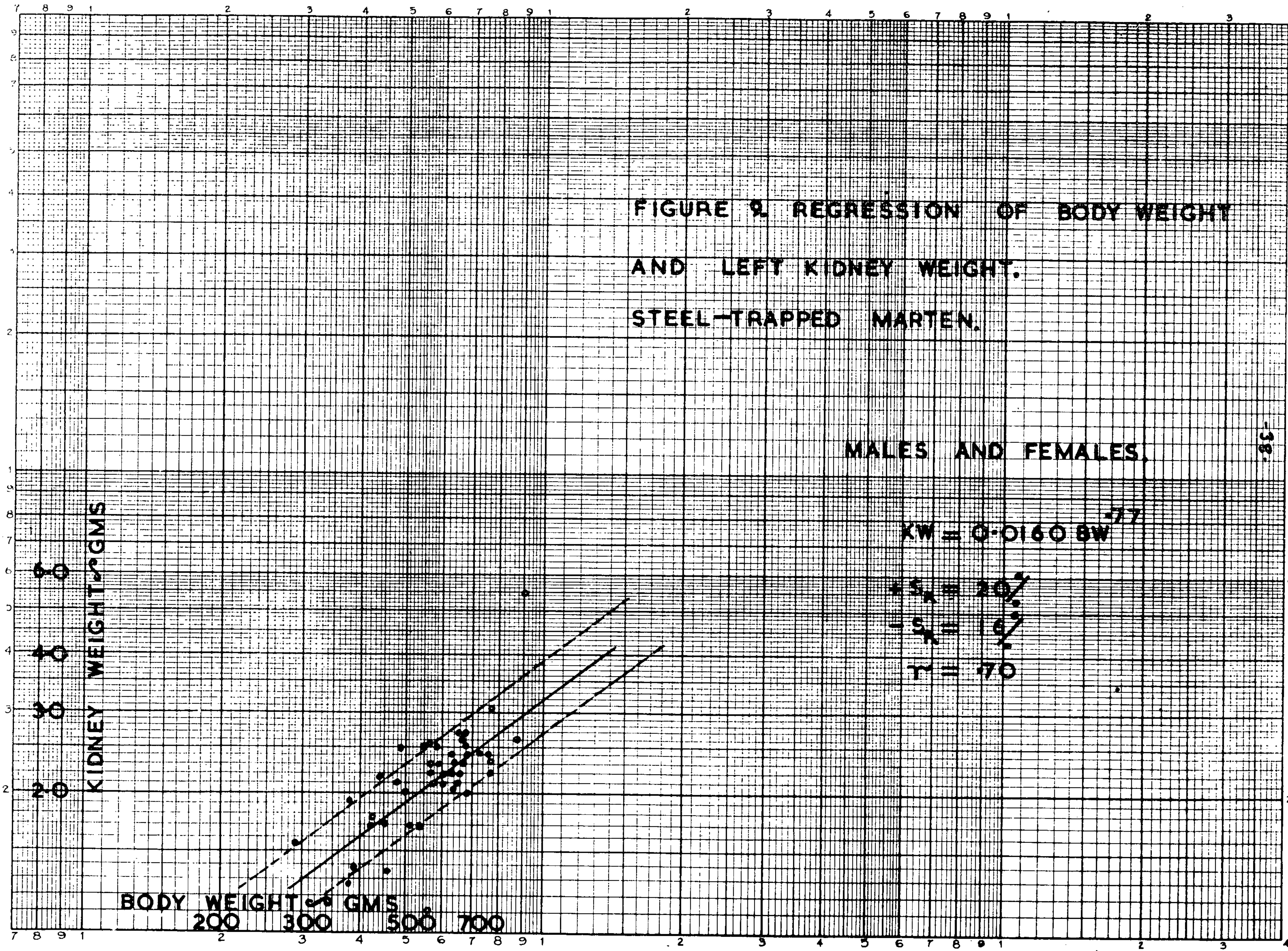


FIGURE 8, REGRESSION OF BODY WEIGHT AND SPLEEN WEIGHT.
STEEL-TRAPPED MARTEN.

Litho'd by Best Mimeograph Co. Ltd., Vancouver, B.C.



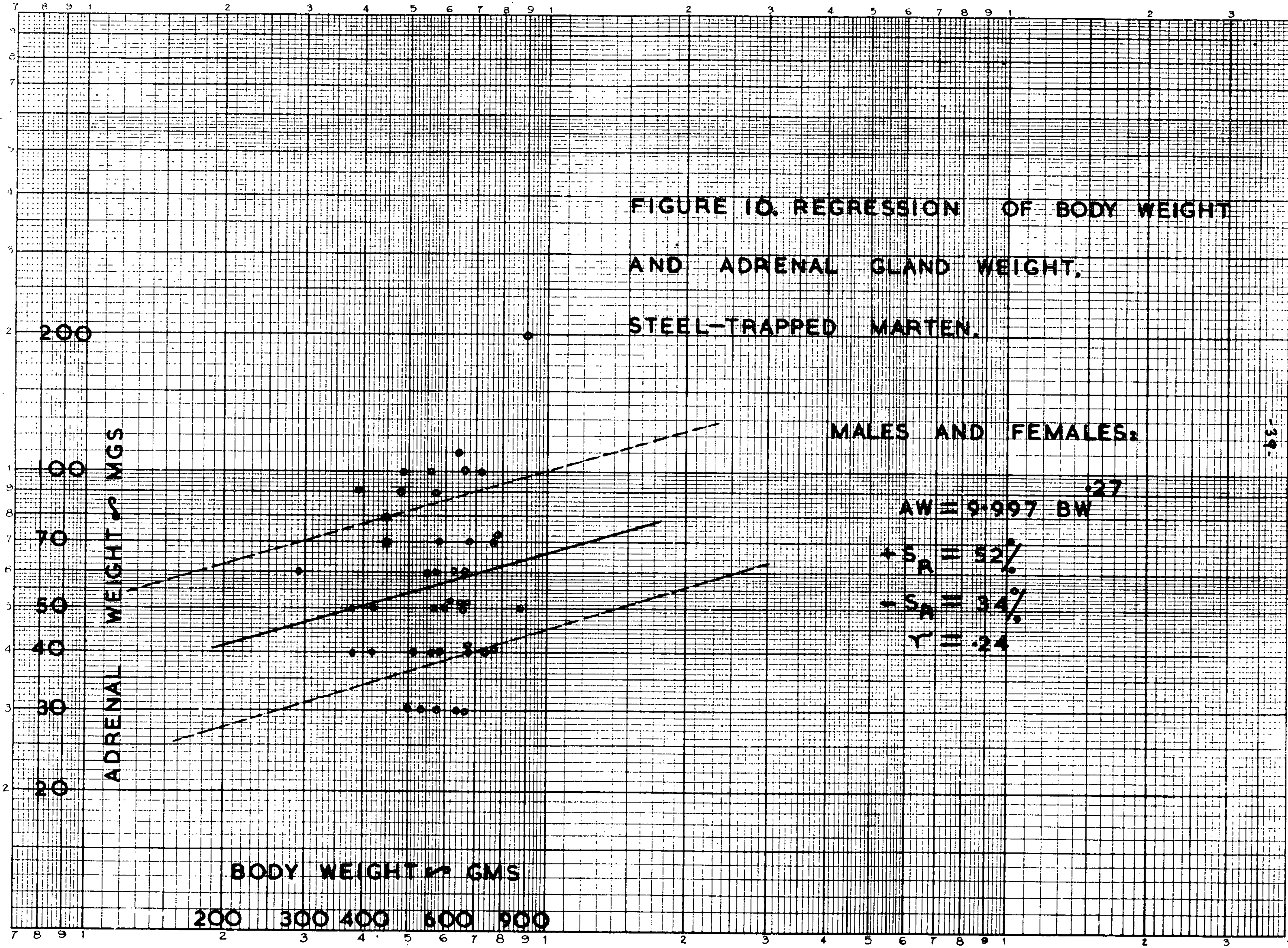
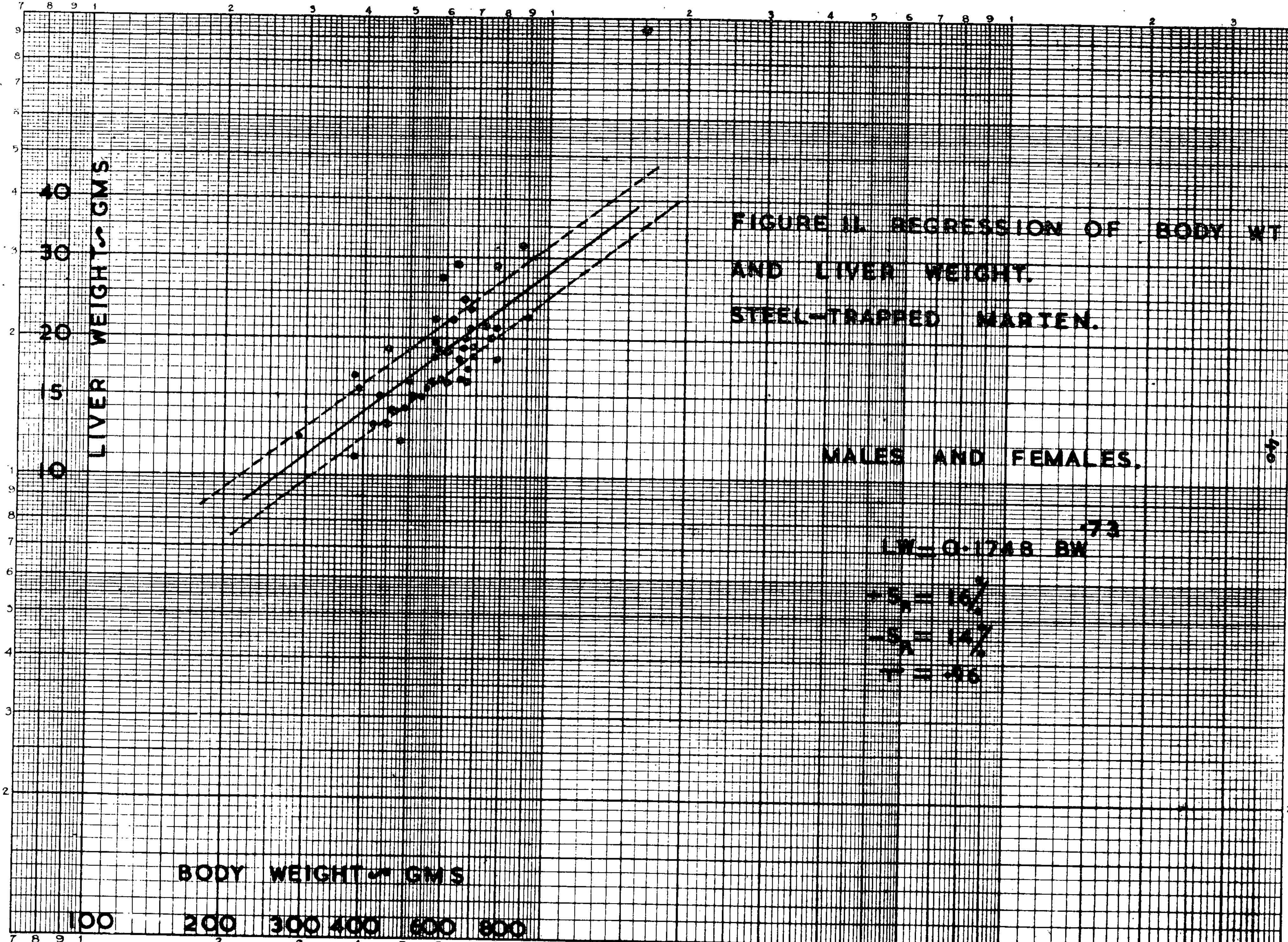


FIGURE 10. REGRESSION OF BODY WEIGHT AND ADRENAL GLAND WEIGHT. STEEL-TRAPPED MARTEN.

Litho'd by Best Mimeograph Co. Ltd., Vancouver, B.C.



Litho'd by Best Mimeograph Co. Ltd., Vancouver, B.C.

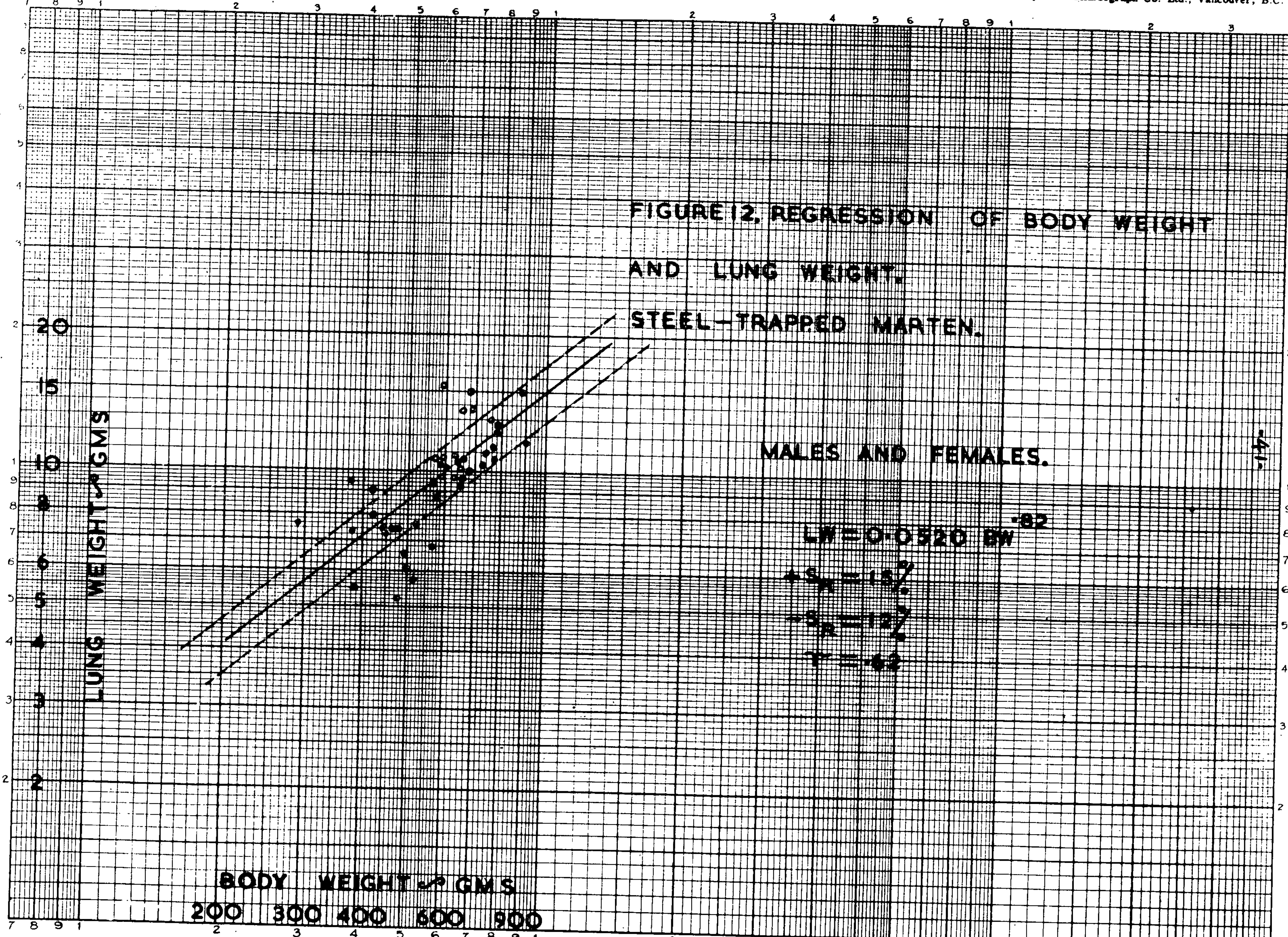


FIGURE 12. REGRESSION OF BODY WEIGHT AND LUNG WEIGHT. STEEL-TRAPPED MARTEN.

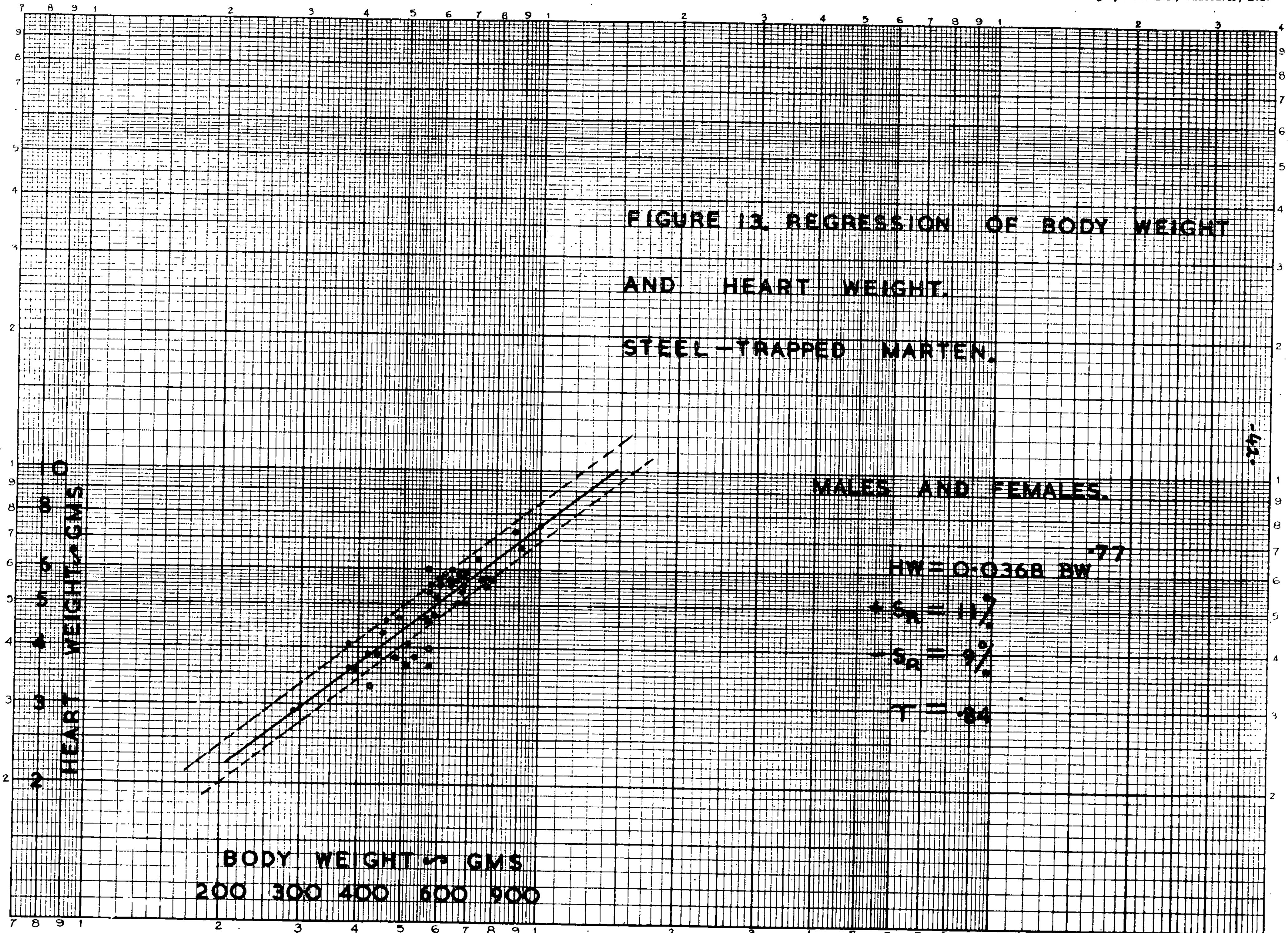


FIGURE 13. REGRESSION OF BODY WEIGHT AND HEART WEIGHT. STEEL-TRAPPED MARTEN.

Litho'd by Best Mimeograph Co. Ltd., Vancouver, B.C.

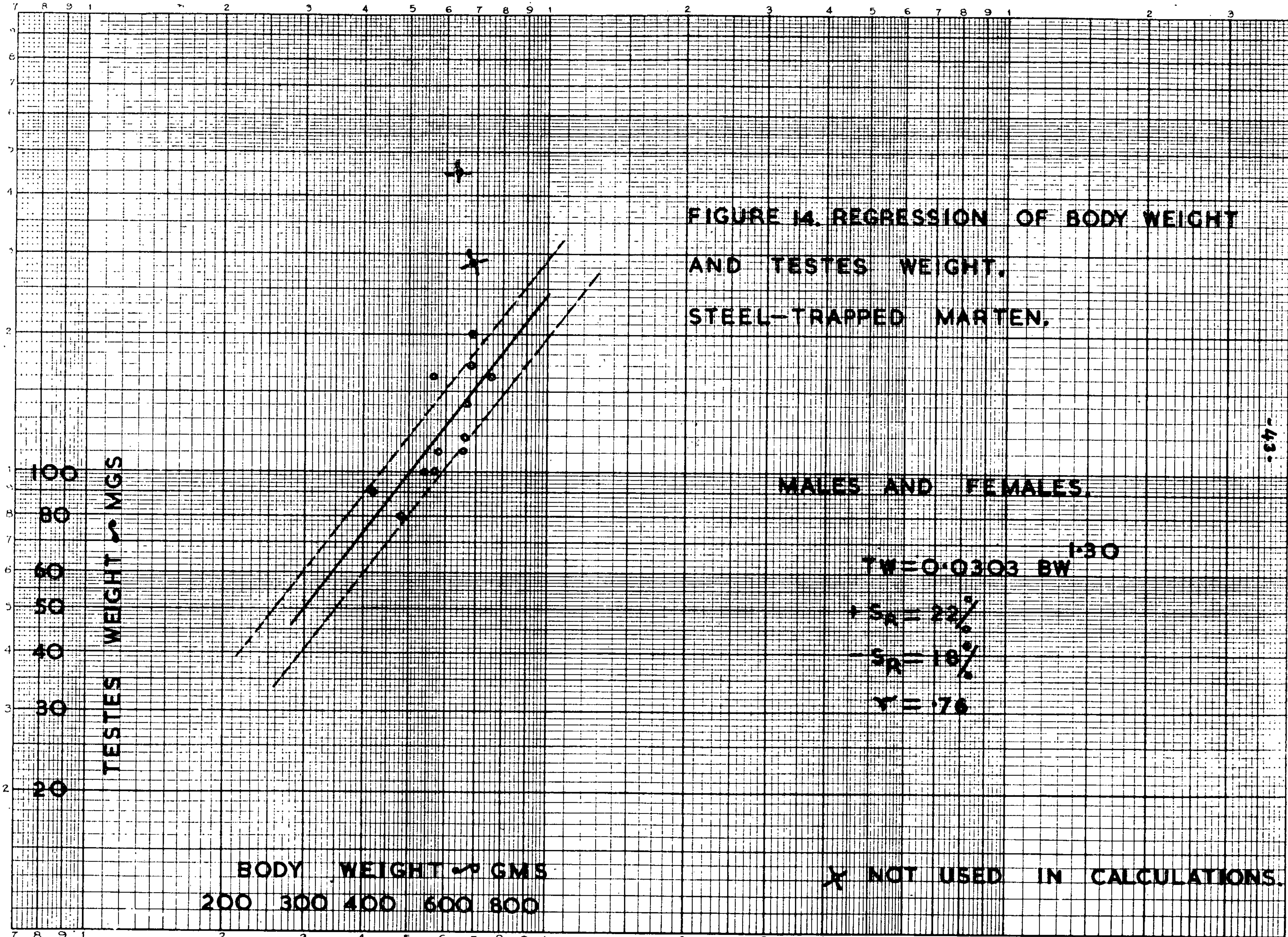


FIGURE 14. REGRESSION OF BODY WEIGHT AND TESTES WEIGHT. STEEL-TRAPPED MARTEN.

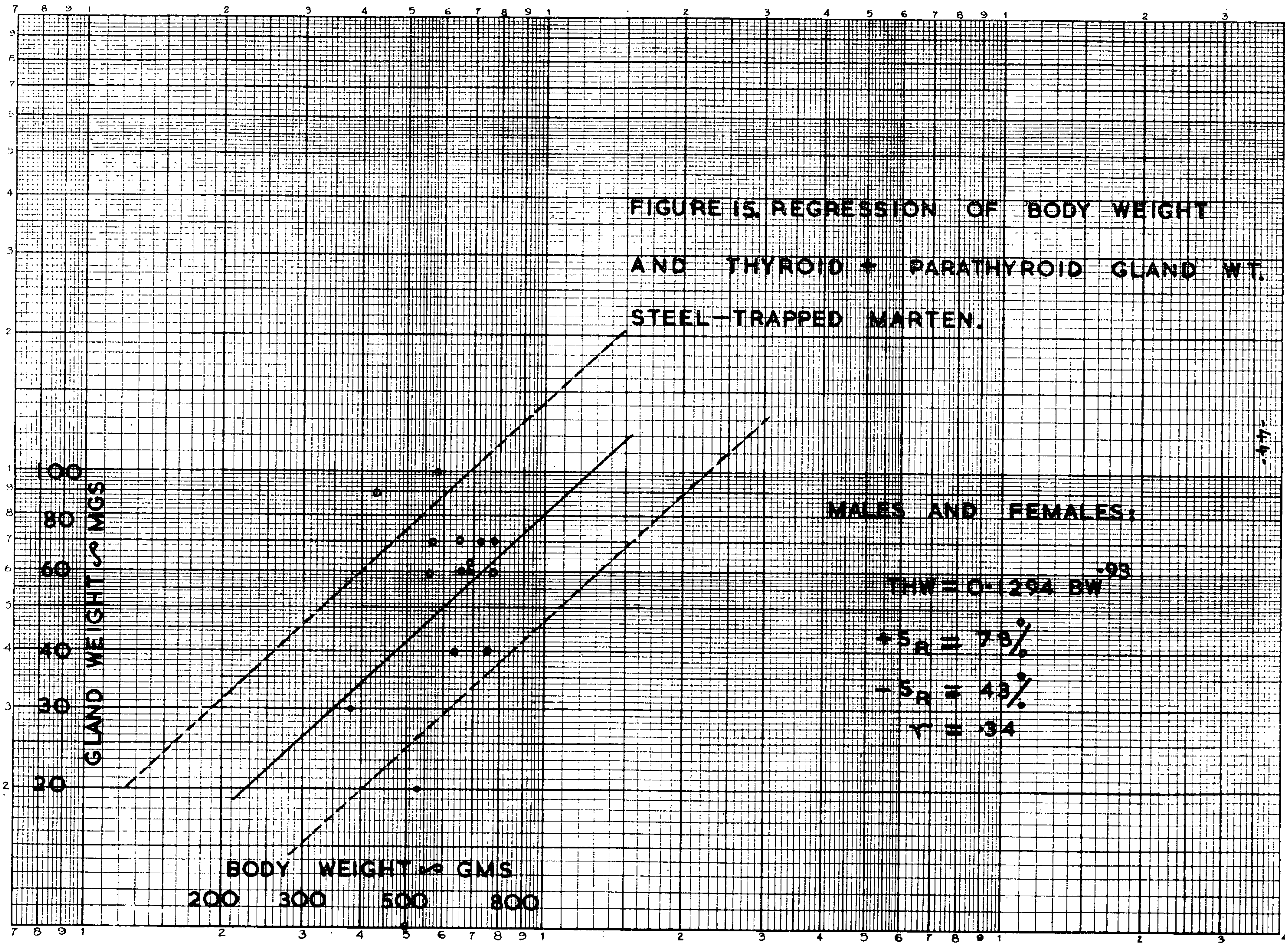


FIGURE 15. REGRESSION OF BODY WEIGHT
AND THYROID + PARATHYROID GLAND WT.
STEEL-TRAPPED MARTEN.
MALES AND FEMALES.
THW = 0·1294 BW·93
+S_R = 78%
−S_R = 43%
r = ·34
GLAND WEIGHT ∽ MGS
100
80
60
40
30
20
BODY WEIGHT ∽ GMS
200
300
500
800

diving species requires larger lungs than a terrestrial animal of similar size. However, the fast running terrestrial animals like the horse and the deer have relatively even larger lungs than the aquatic species. Brody (op. cit.)

(3) The marten, being a highly active terrestrial and semi-arboreal species has a relatively larger heart and lungs than both the mink and Brody's animal. This adaptation in the marten presumably is of great importance to the species because of their mode of hunting. It is undoubtably of advantage to the species that while hunting such prey as the chipmunk and squirrel, sudden manoeuvres be made at high speed. It can be argued that the marten and fisher being both boreal species are not particularly adapted for a highly active existence. In fact the short legs with the heavily clawed feet and the long bushy tail indicate that these species are not externally adapted for high speed in the chase. However it is postulated that because of these disadvantages these two species have evolved a relatively larger heart and larger lungs than either the mink or Brody's typical terrestrial mammal.

(4) The relative weights of the adrenal glands are interesting. From the table it can be seen that the mink has the smallest adrenals, followed by the marten and then by Brody's animal with a predicted weight of 206 mgs. It is possible that the mink and marten really have adrenals of similar size and weight, and that the 120 mgs value for the marten might represent enlarged adrenals due to cortical hypertrophy.

(5) The thyroid weight of the marten is well below that of Brody's prediction. Since this endocrine gland is not affected by stress, Christian (1955), this difference might exist in the live animal in the wild. What implications this might have is not known.

(6) The values for the liver, kidneys and spleen are so similar that comparison is not required.

In Table 8, a male electrocuted mink of 2000 grams is compared with a male 2000 gram fisher and a 2000 gram predicted animal from Brody's table.

From this table it can be seen that:-

(1) The mink again has a relatively smaller heart and lungs than the other two.

(2) The fisher, being in effect just a larger version of the marten, also has a larger heart and lungs, again doubtless adaptations for hunting at high speed.

(3) The adrenals of the Mustelids are again in the same order, with the mink having the smallest, then the fisher and the prediction by Brody being the largest. Here again the value for the fisher may

well represent enlarged adrenals due to "stress". However, it is interesting to find that the mink, which is ranch reared in close proximity to hundreds of other mink, have the smallest adrenals. This might mean that the ranch mink is particularly well adapted to living under such crowded and unnatural conditions. Whether this is the case of the wild mihk is not known.

(4) The values for the thyroids are again similar, with the fisher having significantly smaller glands than those predicted by Brody.

Unfortunately it is not possible to draw up a table comparing the three species of Mustelidae. This is because the largest marten are much smaller than the smallest fisher and extrapolation of the regression line up in the case of the marten and down for the fisher would be highly inaccurate. The lines of best fit are those for the observed data and there is no justification to presume that the extrapolation of the line in either direction would fit the unobserved data.

(d) Prediction tables of organ weights for the marten and fisher

The prediction tables of organ weights of the marten are presented in Appendix II and for the fisher in Appendix III. For the standard errors and correlation coefficients consult Tables 5 and 6.

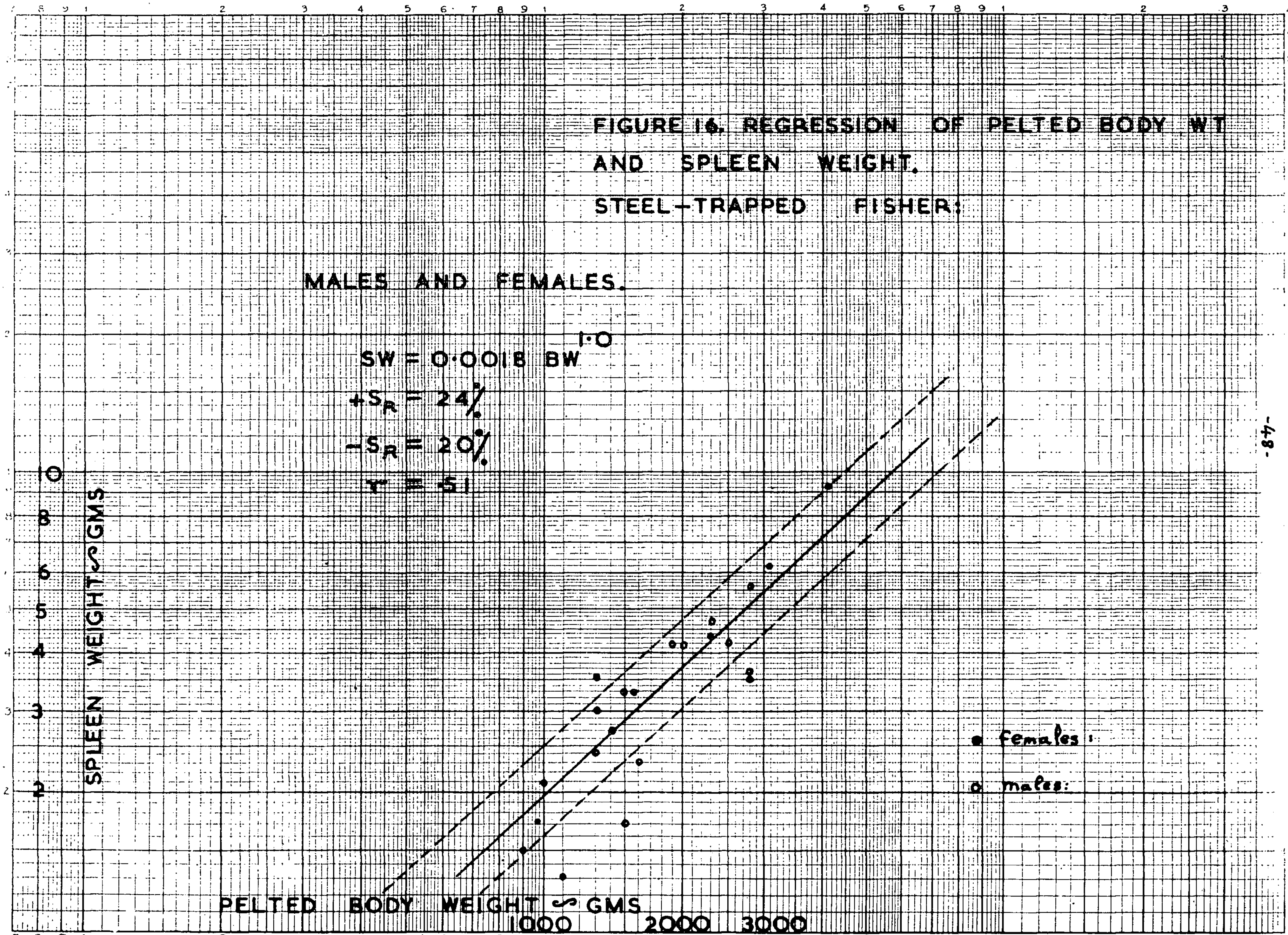


FIGURE 16. REGRESSION OF PELTED BODY WT AND SPLEEN WEIGHT. STEEL-TRAPPED FISHER:

52-416a

Litho'd by Best Mimeograph Co. Ltd., Vancouver, B.C.

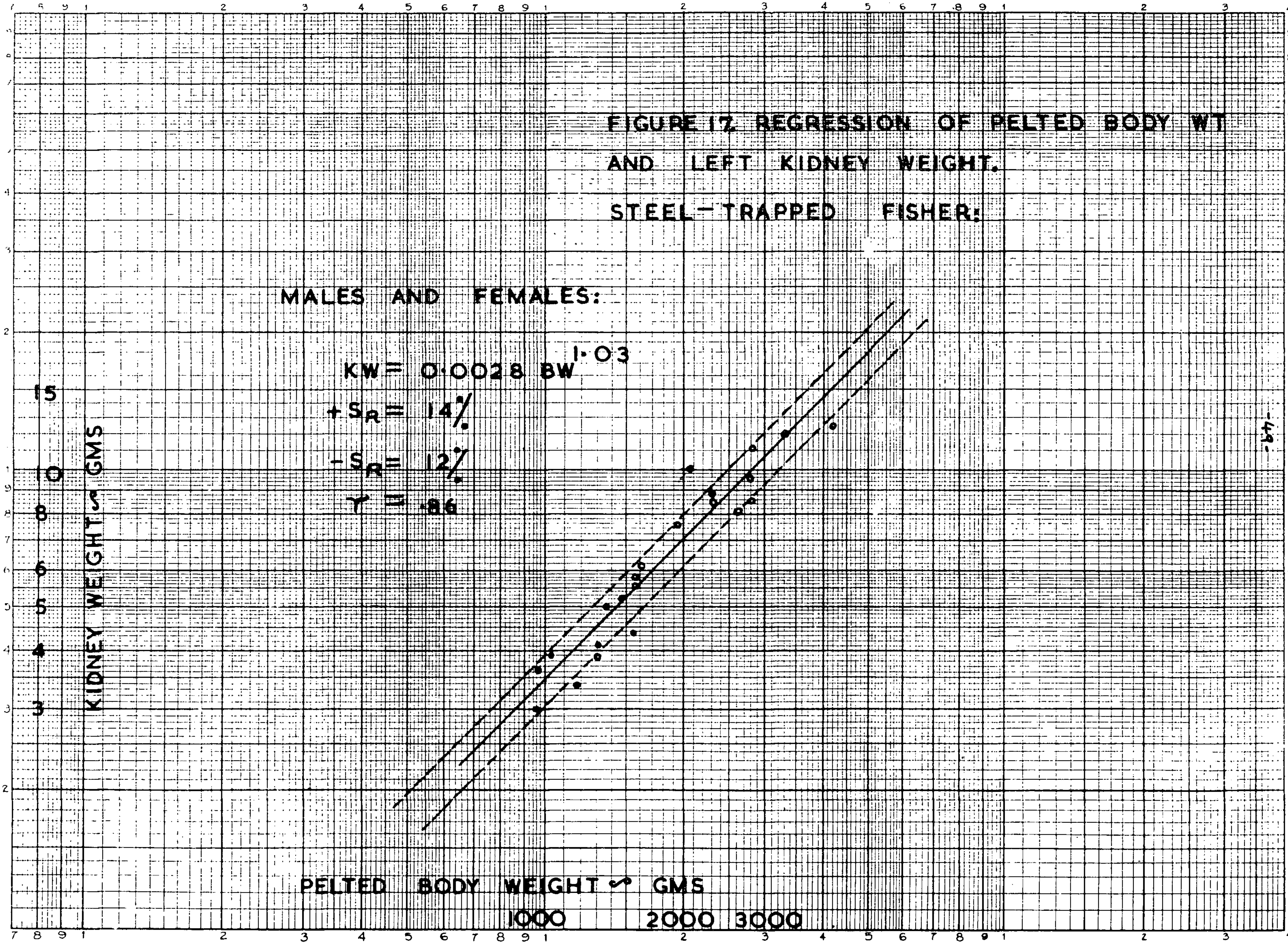


FIGURE 17. REGRESSION OF PELTED BODY WT AND LEFT KIDNEY WEIGHT. STEEL-TRAPPED FISHER:

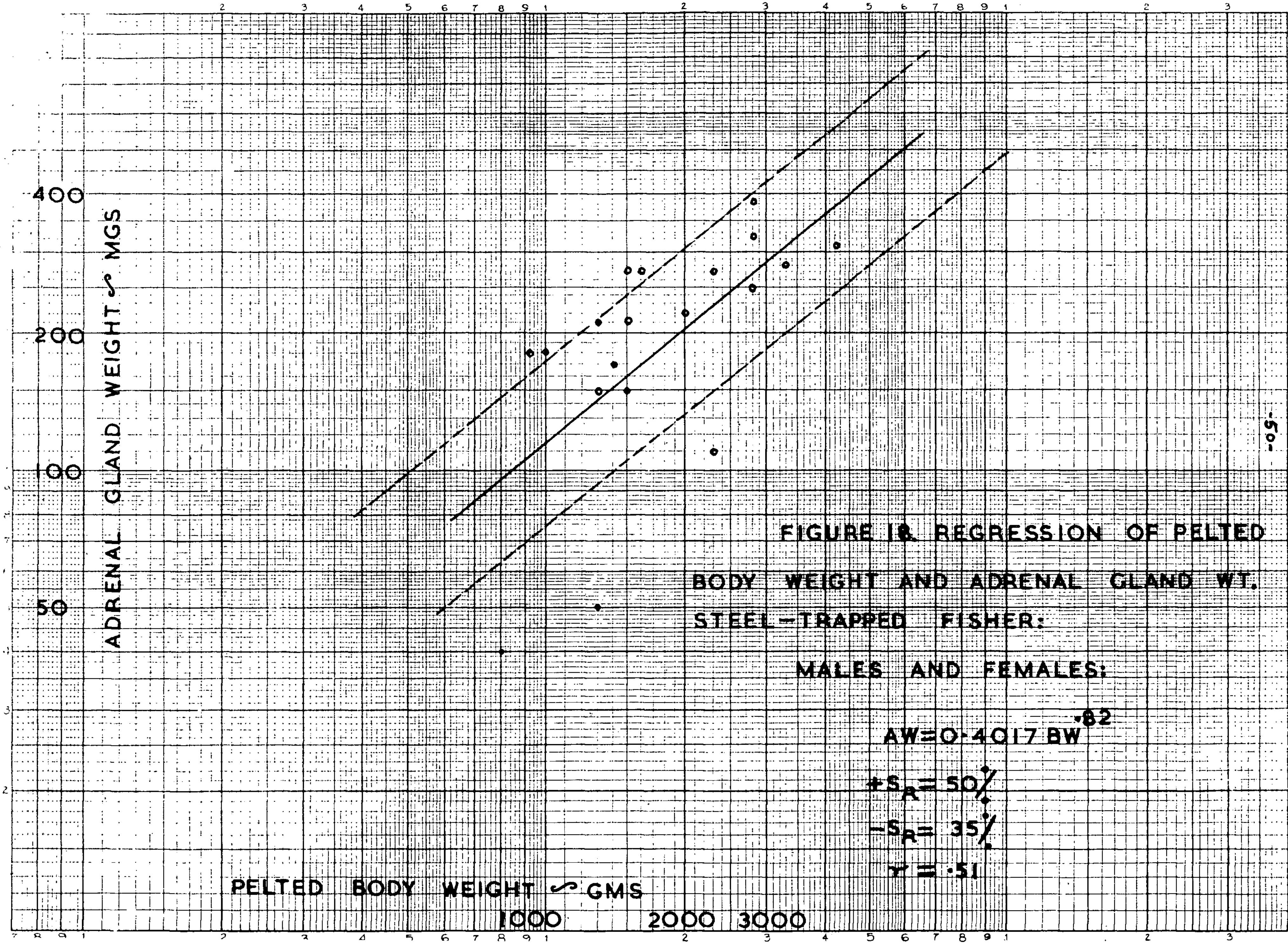
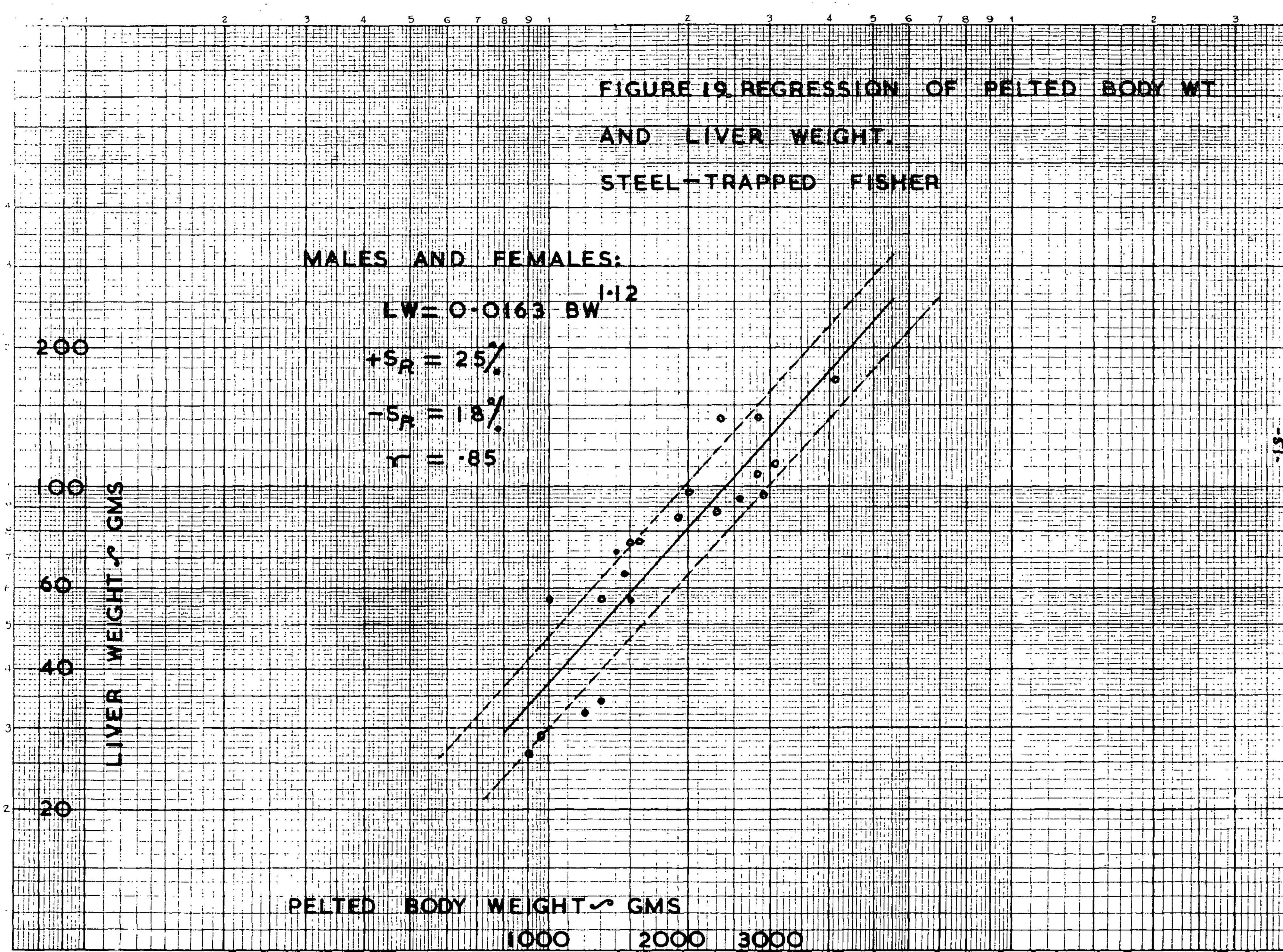


FIGURE 18. REGRESSION OF PELTED BODY WEIGHT AND ADRENAL GLAND WT. STEEL-TRAPPED FISHER: MALES AND FEMALES:

Litho'd by Best Mimeograph Co. Ltd., Vancouver, B.C.



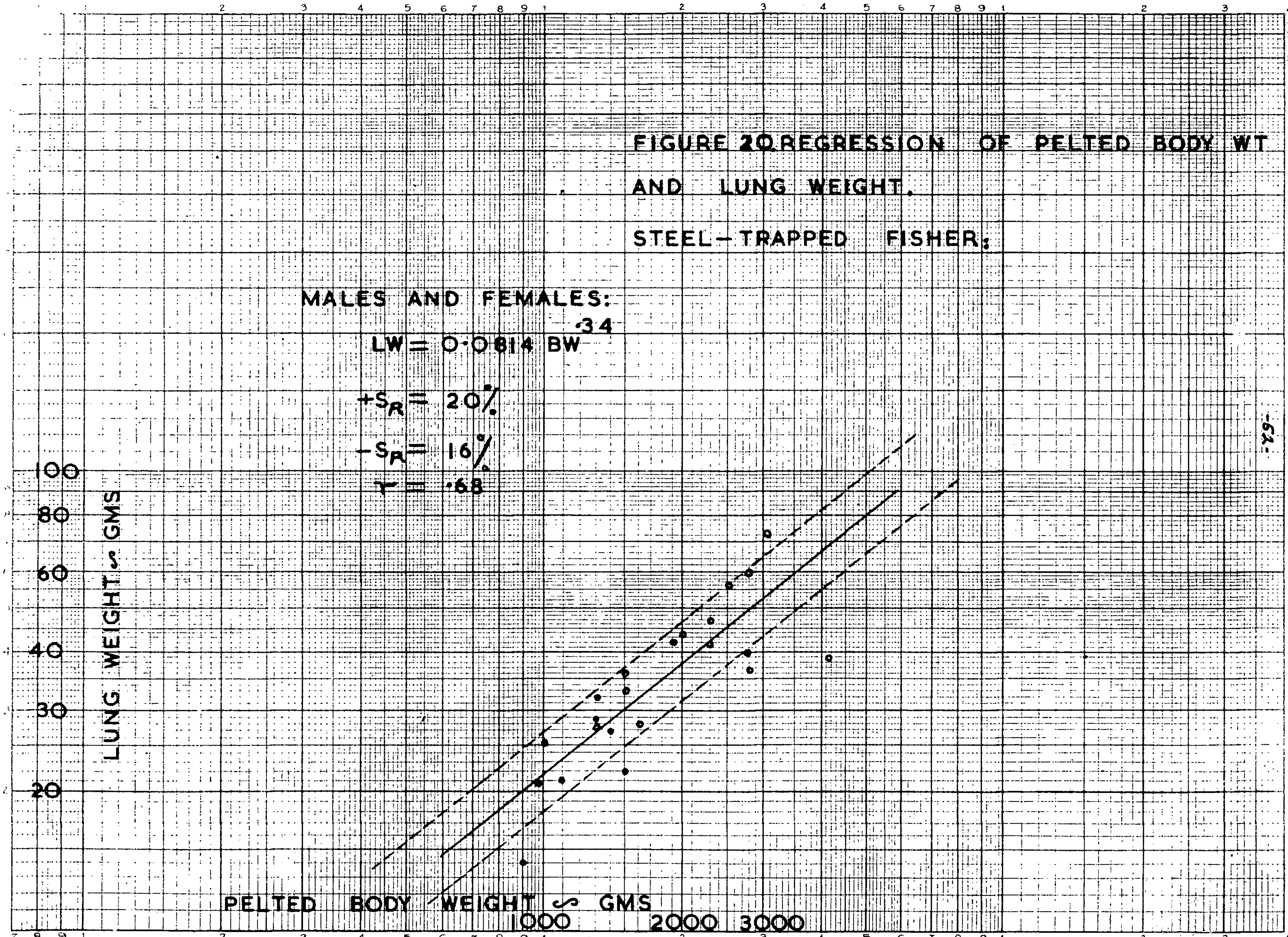


FIGURE 20 REGRESSION OF PELTED BODY WT AND LUNG WEIGHT.
STEEL-TRAPPED FISHER:

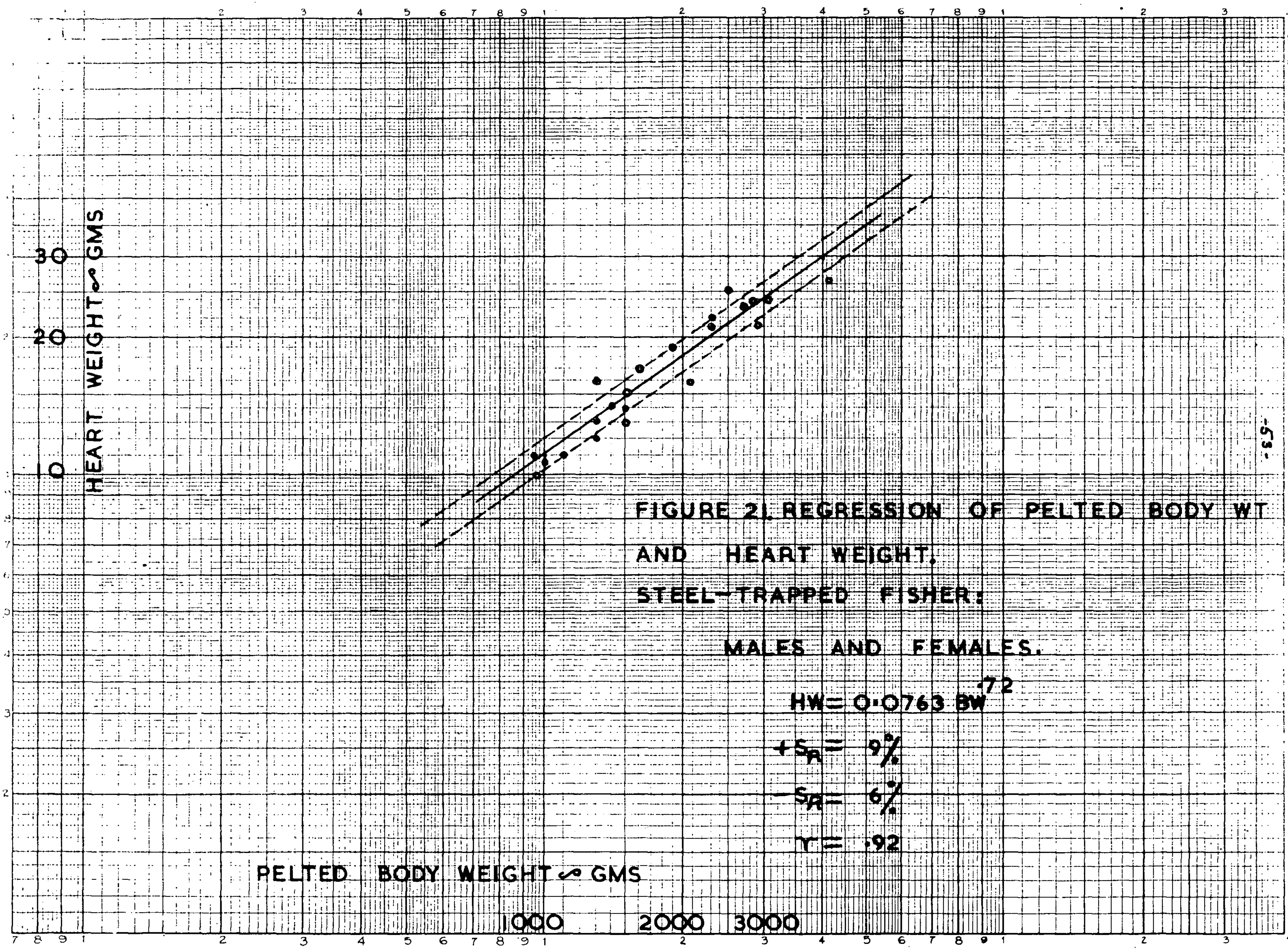


FIGURE 21. REGRESSION OF PELTED BODY WT AND HEART WEIGHT. STEEL-TRAPPED FISHER: MALES AND FEMALES.

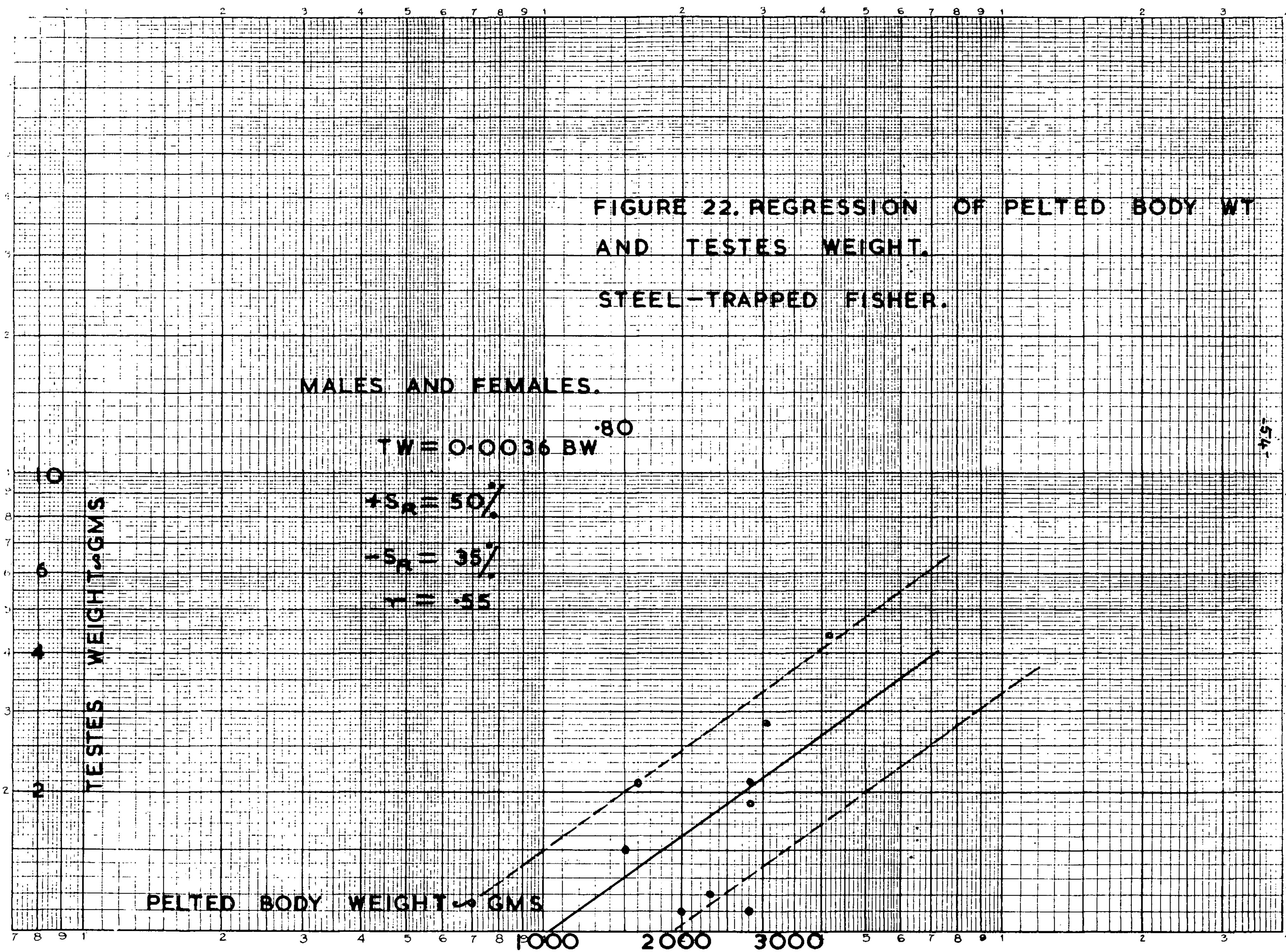


FIGURE 22. REGRESSION OF PELTED BODY WT AND TESTES WEIGHT. STEEL-TRAPPED FISHER.

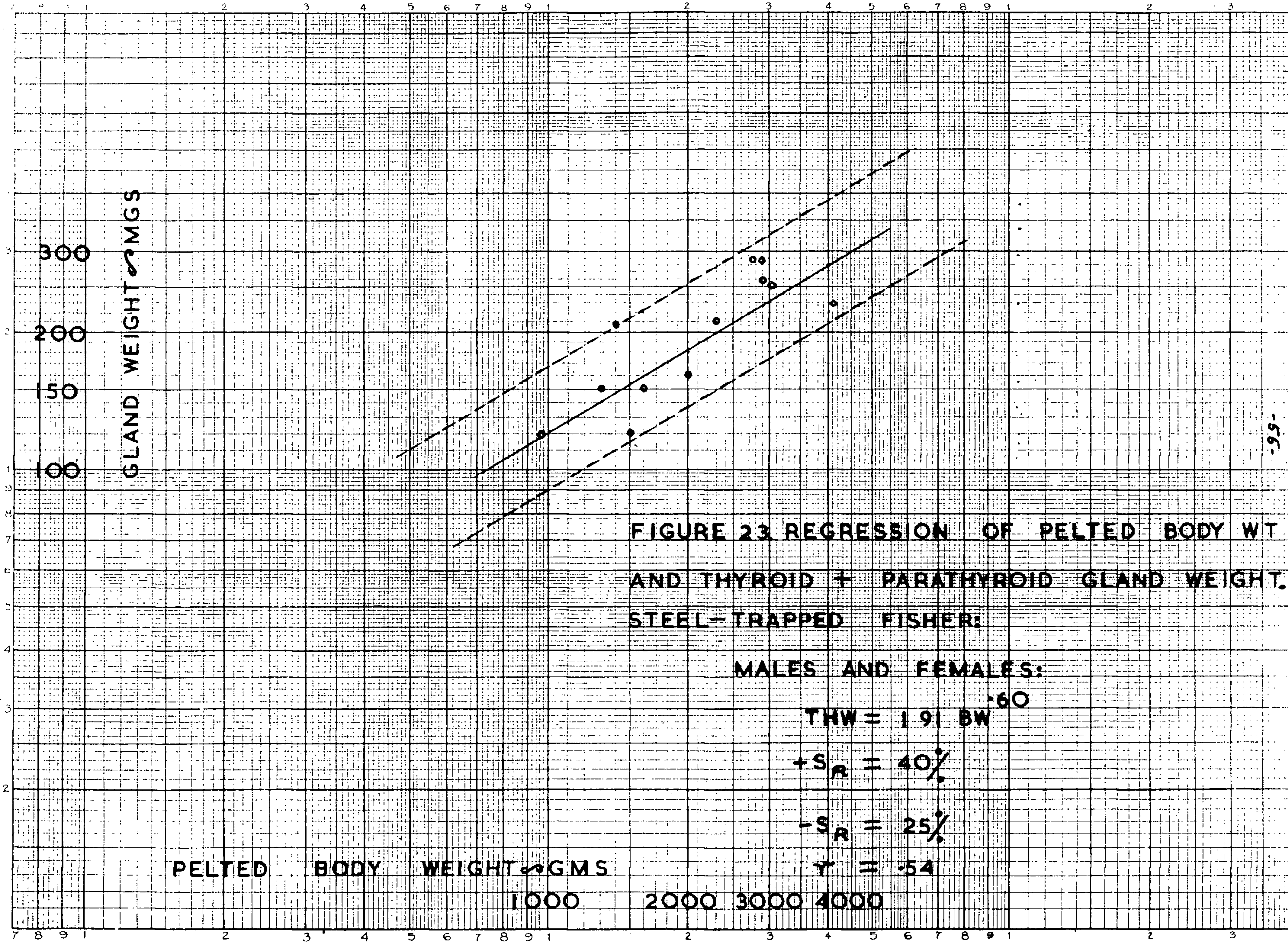


FIGURE 23 REGRESSION OF PELTED BODY WT AND THYROID + PARATHYROID GLAND WEIGHT. STEEL-TRAPPED FISHER:

MALES AND FEMALES:

$THW = 1.91\ BW^{.60}$

$+S_R = 40\%$

$-S_R = 25\%$

$r = .54$

TABLE 8. Species Comparison Table 2. All at 2000 Gms.

Species	Adrenals	Thyroids	Liver	Lungs	Heart	Kidneys	Spleen
Mink	120 mg.	-	66 gm	18 gm	8.4 gm	9.2 gm	3.88 gm
Fisher	300 mg.	150 mg	54 gm	28 gm	14 gm	9.8 gm	2.70 gm
Brody's predict-ions	475 mg	245 mg	61 gm	22 gm	12 gm	13 gm	-

The total weights for the adrenals and kidneys were computed in the same way as in Table 7.

4. The presence of "breaks" or atypical curves in the regression lines

From a study of Figures 1-23 it can be seen that the only natural "breaks" in any of the regression lines are when the electrocuted mink data is broken down into the two sexes. Here the "breaks" take the form of different regression lines for the sexes. They occur in all the organs of the electrocuted mink but some are more pronounced than others.

There were no observed "breaks" in any of the three species similar to those found by Kibler, (1943), in the ovaries and adrenals of rabbits, or in the kidneys of cats by Brody, (1946). These "breaks" in the literature were found mainly on growing animals and represented physiological changes in the growth rate of that particular organ at such times as puberty and maturity. Since the animals used in this study were mainly adults, it is not surprising that similar results were not found.

5. The use of the body weight as the base line for expressing organ weight

From Tables 2-6 it can clearly be seen that when the logarithm of body weight is plotted against the logarithm of organ weight, the coefficients of correlation are high only in such organs as the heart, lungs, liver, stomach and kidney. For such organs as the endocrine glands and the gonads the correlation between the two is very low.

Christian (1955) found a better linear relationship for the adrenal weight by taking the logarithm of the adrenal gland in milligrams and plotting it against the head and body length in centimetres. It is possible that this method could be used for expressing all the endocrine glands, such as the adrenals, thyroids and parathyroids, thymus and pituitary, and also for the testes and ovaries. Further work is needed to test this for the other endocrine glands.

However the base line, body weight, is liable to severe limitations. For example, depending on the pathological and nutritional state of the animal being examined, the body weight could vary considerably. This would have definite effects on the values obtained for the slope of the regression line for the various organs. It would therefore be desirable if a more stable base line could be introduced. The possibilities are limited because this base line must not vary very much even when the animal undergoes severe conditions such as a lowered nutritional state or a pathological condition. The brain weight remains fairly constant in spite of marked changes in the physiological state of the animal. But the brain weight would be virtually impossible to record with any degree of repeatability in the field. Of the larger internal organs the heart has been shown to be the least affected by the status of the animal, and hence appears worthy of consideration as the independent variable against which to express other organs or organ systems.

It was found by the writer that after six days starvation the mean weights of the kidneys, liver and adrenals in rats were reduced by as much as 30%, while the loss in heart weight was only just over 5%. It was therefore decided to relate all the organs to the heart weight in the electrocuted mink to see what kind of equations resulted. These results are presented in Table 9. It is, however, difficult to determine the meaning of such an expression as:

Spleen weight $\approx$ 1.03 Heart weight$^{.43}$ in the female electrocuted mink.

It means that for a 100% increase in the heart weight, there will be only a 43% increase in spleen weight.

It is not known what real value this method of expression has. However it is tentatively offered in the hope that it will give more accurate results when different species are being compared. This new proposal for a base line, which is unaltered by the physiological state of the animal, is tentatively offered without further analysis, in the hope that some future worker will make a detailed study of organ systems for several species in this way.

In this connection some of the results shown in Brody's compilation, (1945), for different species are open to serious criticism and in the writer's opinion are not accurate or reliable. Until there is a standard base line which is not drastically changed by the physiological state of the animal, any comparisons made between species must be open to serious error.

TABLE 9 ORGAN WEIGHT RELATIVE TO HEART WEIGHT IN ELECTROCUTED MINK

Separate values for males and females

Organ weight = a Heart weight^{b}

Organ	Females Regression Equation	Males Regression Equation
Spleen	$SW = 1.03\ HW^{.43}$	$SW = 1.45\ HW^{.44}$
Kidney	$KW = 1.36\ HW^{.42}$	$KW = 0.96\ HW^{.77}$
Adrenal*	$AW = 3.75\ HW^{1.3}$	$AW = 11.0\ HW^{.82}$
Liver	$LW = 10.8\ HW^{.79}$	$LW = 15.9\ HW^{.66}$
Lungs	$LW = 4.76\ HW^{.55}$	$LW = 3.77\ HW^{.76}$
Stomach	$SW = 2.41\ HW^{.33}$	$SW = 1.64\ HW^{.70}$

* Values for the adrenals in milligrams

CONCLUSIONS

1. In comparing mink sacrificed by hydrogen cyanide and by electrocution with the sexes combined, the regression equations for the organs are only statistically significantly different in the case of the spleens and adrenals.

2. When the sexes of cyanide sacrificed mink are treated separately, there is no significant difference between the regression equations for any of the organs.

3. In electrocuted mink the regression equations for the organs with the sexes separate are strikingly different. The values for the exponents of the females varying from 3-5 times those of the male for the same organ.

4. There is considerably more engorgement with blood in the organs of the electrocuted female mink than in the female cyanide sacrificed mink. In the adrenal glands of the former, the zona fasciculata was dramatically more vascularized than the same area in the latter mink. However, the adrenal medulla of the cyanided animals was more vascularized than the same area in the electrocuted animals. For the other organs studied, the lungs, spleen, liver and kidney, the photomicrographs showed more blood in the electrocuted series than in the cyanide series. A quantitative comparison of the vascularization was not attempted.

5. The weights of the adrenal glands of the marten and fisher may have been abnormal due to either engorgement or to cortical hypertrophy due to severe "stress" conditions met with in the traps before death.

Other organs such as the spleen and livers may have been similarly enlarged.

6. The mink, being a semi-aquatic species in the wild state, was found to have relatively a lighter heart and lungs than both the marten and fisher and the predicted values in Brody for a typical terrestrial mammal.

7. The marten and fisher were found to have a relatively larger heart and lungs than both the mink and the predicted values of Brody. This is thought to be an adaptation in these boreal species for active predation.

8. The adrenal glands of the ranch mink were considerably lighter than those of the other two Mustelids and well below those predicted by Brody.

9. The weights of the thyroid and parathyroid glands of the marten and fisher were well below those predicted for terrestrial mammals. This might indicate a peculiarity of the Mustelids or a possible error in Brody's values.

10. The regression of organ weight and body weight with the body weight as the independent variable gives high correlations in the species studied for the heart, lungs, liver, kidney and stomach.

11. Poor correlations were found in the following organs: the spleen, adrenal glands, thyroid and parathyroid glands and the testes. This indicates that prediction tables based on the computed equations for these organs would have little value.

12. Because of the fluctuation in the body weight of an animal due to its nutritional and pathological state, the body weight as the independent variable is considered to be unreliable. The heart weight is tentatively proposed as the new base line against which to express the other organ systems, because with the exception of the brain weight, the heart seems to be the least affected of all the organs in the body by the changing physiological conditions of the animal.

LITERATURE CITED

Addis, T. and H. Gray. Body Size and Organ Weight, Growth, 14:49. 1950

Addis, T. and H. Gray. Body Size and Suprarenal Weight, Growth, 14: 81-92. 1950.

Addis, T. and H. Gray. Body Size and Gonad Weight, Growth, 14:93-106. 1950.

Brody, S. Bioenergetics and Growth, Reinhold Pub. Corp. New York. 1945

Chitty, D. Adverse Effects of Population Density upon the Viability of Later Generations. The Numbers of Man and Animals. Oliver and Boyd, London. 1955.

Christian, J.J. The Effect of Population Size on the Adrenal Glands of Male Mice in Fixed Populations, Amer. Jour. Physiol. 182: 292-300. 1955.

Christian, J.J. and D. E. Davis. The Relationship between Adrenal Weight and Population Status of Norway Rats, Jour. Mammalogy, 37: 4. 1956.

Christian, J.J. A Review of the Endocrine Responses in Rats and Mice to Increasing Population Size. Naval Medical Research Institute, Bethesda, Maryland. Lecture Series 57-2. 1957.

Clarke, J.R. The Effects of Fighting on the Adrenals, Thymus and Spleen of the Vole, Jour. Endoc., 9:114-126. 1953.

Daniel, M.J. The Growth Parabola, $Y = aX^b$, used for relating Body Weights to Thoracic and Abdominal Viscera Weights of Mink, B.A. Thesis, Dept. of Zoology, Univ. of B.C. 1957.

Dawson, J. Splenic Hypertrophy in Voles, Nature, 178:1183-4. 1956.

DuBois, E. On the Relation between the Quantity of Brain and the Size of the Body in Vertebrates, Bull. Soc. Anthropol. Paris. 8:337. 1897.

Fulton, J.F. A Textbook of Physiology, 17th edition. W.B. Saunders Co., London. 1955.

Hatai, S. On the Weights of Viscera of the Albino Rat According to Body Weight, Amer. Jour. Anatomy, 15:87. 1913.

Huxley, J.S. Problems of Relative Growth, Dial Press. New York, 1932.

Jellinck, S. Electrical Accidents from the Clinical and Forensic Standpoint, Proc. Roy. Soc. Med. 6:17. 1913.

Kibler, H.H. and A. J. Bergman. Relation of Certain Endocrine Glands to Body Weight in Growing and Mature New Zealand White Rabbits. Endocrinology, 33:250. 1943.

Lambert, R. and G. Teissier. Theorie de la Similitude Biologique, Ann. Physiol. et Physico-chim. Biol., 2:22. 1927.

MacWilliam, J.A. Discussion on Pathological Changes Produced by Electrical Shock, Proc. Roy. Soc. Med., 15:49. 1922.

Mixner, J.P. and A. J. Bergman. Relation of Certain Endocrine Glands to Body Weight in Growing and Mature Guinea Pigs. Endocrinology, 32:298. 1943.

Reese, J.J. Textbook of Medical Jurisprudence and Toxicology. Blakiston, Philadelphia. 1906.

Rogers and Richter. Anatomical Comparison between Adrenal Glands of Wild Norway Rats and Domestic Norway Rats. Endocrinology 42: 46-55. 1948.

Selye, H. The General Adaptation Syndrome, Jour. Clin. Endocrinology, 6:117-230. 1946.

Sholl, D.A. Regularities in Growth Curves, including Rythms and Allometry. Dynamics of Growth Processes. Princeton University Press, Princeton. 1954.

Smith, S. and F. S. Fiddes. Forensic Medicine. Churchill Press. London. 1949.

Snedecor, G.W. Statistical Methods. 5th edition. Iowa State Press, Iowa. 1956 .

Urquhart, R.W.I. Experimental Electric Shock. Jour. Industrial Hygiene. 7:65. 1927.

Urquhart, R.W.I. Pathological Symptoms of Electric Shock. Ontario Medical Review. 18:4. 1951.

Appendix I Prediction Table of Organ Weights of Electrocuted Mink calculated from the regression equations with sexes separate. (The wts of the adrenal gland and kidney refer to left organ only)

	Spleen wt (gms)	Adrenal wt (mgs)	Liver wt (gms)	Lungs wt (gms)	Heart wt (gms)	Kidney wt (gms)
Standard Error	40% -28%	70% -42%	20% -17%	13% -12%	24% -12%	23% -17%
Body weight Females:						
500 gms	1.1	12.9	13.7	6.5	2.9	1.1
550	1.2	14.5	16.4	7.1	3.1	1.3
600	1.4	16.0	19.4	7.7	3.2	1.5
650	1.5	17.7	22.6	8.4	3.4	1.7
700	1.6	19.2	26.0	9.0	3.5	2.0
750	1.7	21.0	29.6	9.6	3.6	2.3
800	1.8	22.7	33.5	10.2	3.8	2.6
850	1.9	24.4	37.6	10.8	3.9	2.9
900	2.0	26.1	41.9	11.4	4.0	3.3
950	2.2	27.7	46.1	12.0	4.2	3.6
1000	2.3	29.6	51.2	12.6	4.3	3.9
Males: Standard Error	60% -37%	50% -33%	12% -11%	16% -14%	9% -8%	19% -16%
800	2.4	38.4	39.2	11.8	3.8	3.2
850	2.4	39.6	40.6	12.2	4.0	3.2
900	2.5	40.7	41.9	12.5	4.2	3.3
950	2.6	41.7	43.1	12.8	4.4	3.4
1000	2.7	42.8	44.5	13.0	4.6	3.4
1050	2.7	43.8	45.7	13.4	4.8	3.5
1100	2.8	44.9	46.9	13.7	5.0	3.6
1150	2.9	45.8	48.1	13.9	5.2	3.6
1200	2.9	46.7	49.2	14.1	5.4	3.7
1250	3.0	47.7	50.1	14.4	5.6	3.7
1300	3.1	48.6	51.5	14.7	5.8	3.8
1350	3.1	49.4	52.6	14.9	6.0	3.9
1400	3.2	50.3	53.7	15.1	6.1	3.9
1450	3.2	51.2	54.7	15.4	6.3	4.0
1500	3.3	52.0	55.8	15.6	6.5	4.0
1550	3.3	52.8	56.8	15.9	6.7	4.1
1600	3.4	53.6	57.9	16.1	6.9	4.1
1650	3.5	54.4	58.9	16.3	7.1	4.2
1700	3.5	55.2	59.8	16.5	7.3	4.2
1750	3.6	56.0	60.9	16.7	7.4	4.3
1800	3.6	56.8	61.8	16.9	7.6	4.3
1850	3.7	57.5	62.8	17.2	7.8	4.3
1900	3.7	58.3	63.7	17.4	8.0	4.4
1950	3.8	59.0	64.6	17.6	8.2	4.4
2000	3.8	59.7	65.6	17.8	8.3	4.5
2050	3.9	60.4	66.5	17.9	8.5	4.5
2100	3.9	61.1	67.4	18.1	8.7	4.6
2150	4.0	61.8	68.3	18.3	8.9	4.6
2200	4.0	62.5	69.2	18.6	9.0	4.6

APPENDIX II Prediction Table of Organ Weights for Steeltrapped Marten
Calculated from the regression equations in Table 5.
Males and females combined

	Kidney* (gms)	Heart (gms)	Lungs (gms)	Liver (gms)	Adrenal** (mgs)	Thyroids*** (mgs)	Testes**** (mgs)	Spleen (gms)
Standard Error	20% -16%	11% -9%	15% -12%	16% -14%	52% -34%	78% -43%	22% -18%	18% -16%
Body weight (gms)								
300	1.3	2.9	5.6	11.2	46.6	26.0	50.4	0.7
350	1.5	3.3	6.3	12.4	48.6	30.0	61.6	0.7
400	1.6	3.7	7.1	13.8	50.4	34.1	73.2	0.8
450	1.7	4.1	7.8	15.1	52.0	37.9	85.4	0.8
500	1.9	4.4	8.5	16.3	53.5	41.8	97.9	0.9
550	2.0	4.7	9.2	17.5	54.9	45.7	110	0.9
600	2.2	5.1	9.9	18.6	56.2	49.6	124	1.0
650	2.3	5.4	10.1	19.5	57.4	53.4	137	1.1
700	2.5	5.7	11.2	20.8	58.6	57.2	151	1.1
750	2.6	6.0	11.8	21.9	59.7	61.0	165	1.1
800	2.7	6.3	12.4	23.0	60.8	64.8	180	1.2
850	2.9	6.6	13.1	24.0	61.7	68.5	195	1.2
900	3.0	6.9	13.7	25.0	62.7	72.3	210	1.3

* These weights for the kidney refer to the left kidney only. The right kidney is approximately 4% heavier than the left.

** The adrenal weights also refer to the left side only. It is assumed that the two are of approximately the same weight.

*** The thyroid weights are the combined weights of the two thyroids and the two parathyroids.

**** The weights for the testes are the weights without the vasa deferentia.

APPENDIX III — Prediction Table of Organ Weights for Pelted Fisher
Calculated from the regression equations in Table 6
Males and females combined

	Kidney (gms)	Heart (gms)	Lungs (gms)	Liver (gms)	Adrenal (mgs)	Thyroids (mgs)	Testes (gms)	Spleen (gms)
Standard Error	14% -12%	9% -6%	20% -16%	25% -18%	50% -35%	40% -25%	50% -35%	24% -20%
Pelted Body Weight								
1000	3.4	11.0	21.6	37.5	115	120	0.9	2.0
1100	3.8	12.0	23.2	41.5	125	127	1.0	2.1
1200	4.2	12.5	25.0	45.0	132	134	1.1	2.3
1300	4.5	13.2	26.5	50.0	142	140	1.2	2.5
1400	4.9	14.0	28.5	54.0	150	148	1.2	2.7
1500	5.2	14.8	30.0	58.0	160	152	1.3	2.8
1600	5.6	15.5	31.5	63.0	170	160	1.4	3.0
1700	6.0	16.2	33.2	68.0	178	165	1.4	3.2
1800	6.4	17.0	35.0	72.0	188	170	1.5	3.4
1900	6.7	17.4	36.0	76.0	195	175	1.5	3.5
2000	7.0	18.0	37.5	81.0	205	180	1.6	3.7
2100	7.4	18.9	39.0	86.0	210	188	1.6	3.9
2200	7.8	19.5	41.0	90.0	220	195	1.7	4.0
2300	8.2	20.0	42.0	95.0	228	200	1.7	4.2
2400	8.5	20.8	44.0	100	235	204	1.8	4.4
2500	8.9	21.2	45.0	104	245	210	1.9	4.6
2600	9.2	22.0	46.5	110	250	215	1.9	4.7
2700	9.6	22.5	48.0	114	260	220	2.0	4.8
2800	10.0	23.0	49.0	118	270	224	2.0	5.1
2900	10.3	23.5	51.0	122	278	228	2.1	5.2
3000	10.6	24.0	52.0	128	285	230	2.1	5.4
3100	11.0	25.0	54.0	132	290	235	2.2	5.6
3200	11.4	25.5	55.0	138	300	240	2.2	5.8
3300	11.8	26.0	56.5	142	310	245	2.3	6.0
3400	12.2	26.5	58.0	148	315	250	2.3	6.1
3500	12.5	27.0	59.5	151	325	255	2.4	6.2
3600	12.9	27.5	61.0	156	330	260	2.4	6.4
3700	13.2	28.3	62.0	162	340	265	2.5	6.6
3800	13.5	29.0	64.0	168	345	270	2.5	6.8
3900	14.0	29.5	65.0	172	355	274	2.6	7.0
4000	14.5	30.0	66.0	178	360	280	2.6	7.2

Details on the kidney, adrenals, thyroids and testes are the same as for the marten.