1944

Heredity As A Disease Control

K. T. Maddy
Iowa State College

Follow this and additional works at: https://lib.dr.iastate.edu/iowastate_veterinarian

Part of the Veterinary Preventive Medicine, Epidemiology, and Public Health Commons

Recommended Citation
Maddy, K. T. (1944) "Heredity As A Disease Control," Iowa State University Veterinarian: Vol. 7 : Iss. 2 , Article 4.
Available at: https://lib.dr.iastate.edu/iowastate_veterinarian/vol7/iss2/4

This Article is brought to you for free and open access by the Journals at Iowa State University Digital Repository. It has been accepted for inclusion in Iowa State University Veterinarian by an authorized editor of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
SELECTIVE breeding for resistance to disease has been suggested as a method of disease control in animals. In recent years, amazing work has been done in the plant field in developing plants that are resistant to many of the diseases that once were considered fatal to the plants' life. Comparatively little work has been done in the animal field along these lines.

When Pasteur noted that Algerian sheep were relatively more resistant to *Bacillus anthracis* infection than other strains, he suggested that this was a case of inherited resistance.

Variations in host resistance had been widely discussed prior to the last half century, but little had been done in selective breeding for resistance to disease. With the relatively recent development of biologics, medicines, and quarantine methods, the idea of selective breeding in the field of disease prevention has been pushed to the background.

**Resistant Individuals**

In the case of the test and slaughter method of eradication of tuberculosis and brucellosis of cattle, some men have expressed the idea that this removes the susceptible animals and keeps the resistant individuals; however, as a matter of fact, the opposite has been shown to be true. The strains of animals never exposed to the disease and recover seem, over a period of time, to transmit an inheritable resistance.

Certain strains, certain breeds, and of course certain species show considerable variation in disease resistance. Selection of these known strains or breeds for use in the development of populations is very useful in securing resistant stock of another strain or breed.

One of the experimental difficulties is the task of distinguishing between the inheritance of resistance to bacterial infections and active or passive acquired immunity.

**Inheritance Factors**

There seem to be some differences in the opinions of various investigators as to whether inability of certain individuals to contract disease is due to the inheritance of a resistance to disease in general, or merely of a resistance to a specific disease entity. In the light of recent research, it has been shown that there can be inheritance of general disease resistance and also of specific disease resistance.

Gowen's theory of inheritance maintains that it is the fortuitous combination of separate factors that extend the range of resistance to different agents. It is thus not necessarily due to separate genes, but to a combination of genes. This accounts for the difficulty of obtaining definitely resistant animals.

It should be remembered that progeny testing is equally effective in breeding for any hereditary physiological characteristic. It is known that the genetic factors of minor significance in animal breeding, such as coat color, can be relatively easily detected, although quite complicated. Those factors of more economic importance, as is disease resistance, are also quite complicated but unfortunately are not always so easy to detect.
Disease resistance falls into much the same class as constitution; for over a period of time, animals exposed to certain diseases seem to become resistant to that disease.

Prior to 1930, a considerable amount of research had been done, but the results, when examined, do not seem to give definite proof of inheritance of resistance to pathological conditions. Since then experimental evidence has been more encouraging.

**Experimental Evidence**

Due to the economy and relative ease of experimental procedure, much work has been done on the mouse. Two important series of experiments have been done on the domestic fowl, and a few experiments have been successfully carried out with the large domestic animals.

Some examples of the experimental work carried out is summarized below.

*Bacillus enteritidis* infection of mice was a condition used by Webster to breed susceptible and resistant strains. By making appropriate crosses, segregation of susceptible and resistant factors, clearly demonstrated the hereditary basis of the results.

Schott studied the effect of selection for resistance to controlled doses of *Salmonella aenterycke* in mice. A considerable amount of resistance was developed, but after a time further decrease in resistance stopped. Hetzer took up the experiment and was able to increase the amount of resistance in mice. His experiments suggested that there is a definite trend toward homozygosity in the resistant strains. These two experiments seemed to show that mouse typhoid is governed by multiple genetic factors.

Interactions between host and pathogen in mouse typhoid caused by *Salmonella typhimurium* were studied by Zelle. By passing organisms through hereditarily resistant and susceptible hosts, the virulence was not decreased in either case. Injection of virulent and non-virulent strains of bacteria resulted in only the virulent types being passed by the host.

A pronounced correlation was found between resistance and the numbers of leucocytes characteristic for the given strain by Gowen and Calhoun in experiments with mouse typhoid. The higher the leucocyte count, the greater was the resistance. Less correlation was found between the number of erythrocytes or the proportions of the various types of leucocytes.

In working with *S. typhimurium* infection in mice, Weir has demonstrated that the resistant strains owe their resistance to different combinations of genes, some of which determine resistance to the growth of live organisms; others determine resistance to toxins, and still others control the production of agglutinins.

Gowen and Schott have shown in work on two strains of mice that the strain more resistant to pseudorabies virus was more susceptible to *Bacillus aenterycke*. These results are suggestive of separately inherited factors.

In experiments upon rabbits by Cole, strains which were as high as 85 per cent resistant to *Brucella abortus* were developed when doses of culture sufficient to cause abortion in other rabbits were injected.

**Resistance**

Studies of resistance to *Salmonella pullorum* in chickens was undertaken by DeVolt, Quigley, and Byerly. Their experiments demonstrated that strains of relatively pullorum-resistant chickens may be developed by artificial selection. They found that strains of relatively resistant chickens develop by natural infection, and that "Pullorum Clean" flocks produced chicks which were relatively susceptible to pullorum induced by artificial exposure. However, it is interesting to note that they concluded from their experiments that development of *S. pullorum* resistant strains are not now a satisfactory substitute for control and eradication programs by agglutination tests.

Roberts and Card, in working with poultry in breeding for resistance to *Shigella gallinarum* infection, demonstrated
that strains of poultry could be developed that show resistance to that infection. Gowen, Lindstrom, and Maw have shown that *S. gallinarum* infection of the fowl can be controlled by choosing genetically resistant strains of birds through blood cell counts.

In working with fowl paralysis, Hutt, Cole, and Bruckner reduced the mortality rate due to fowl paralysis by 50 per cent by selective breeding over a period of three years.

A line of single comb White Leghorns having resistance to disease in general, particularly those diseases belonging to the leukemia complex, has been developed as a result of 8 years selection by Bearse, McClary, and Miller. Mortality during the pullet laying year in a control line was shown to be 50 per cent while in the disease resistant line it was only 30 per cent.

**Selection for Viability**

Marble was also interested in breeding poultry for viability. After 5 years of selection of breeders from the most viable families of single comb White Leghorns and Barred Plymouth Rocks, the mortality in the laying flock was cut in half.

Several experiment stations, including Pennsylvania, New York, Massachusetts, and Iowa, have reported various degrees of success in reducing the incidence of fowl paralysis in their flocks by breeding. There seems little doubt that it is possible to select strains of chickens which differ in their resistance to the avian leukemia complex.

Jeffrey, Beaudette, and Hudson have made considerable progress in segregating two lines of White Leghorns that differ materially in incidence of fowl paralysis and also in laying house mortality from all causes. Paralysis resistant strains have been developed by reducing the incidence in infected strains of previously paralysis-free lines by approximately 90 per cent and in strains of previously paralysis-infected lines by 65 per cent. About one-fourth of this reduction is attributed to breeding, and three-fourths to other causes.

Attempts to produce strains of hogs resistant to hog cholera have been made on a small scale at the Iowa and Illinois Agricultural Experiment Stations. Neither experiment was conducted with sound genetic methods, and both failed. The results of the Illinois experiment gave the investigators hope that when the inherited immunology is better understood, work may be done with more successful results.

Cameron, Hughes, and Gregory in a course of investigations on the epidemiology and course of contagious abortion in swine due to *Brucella suis* found one boar and two sows which could not be infected with the organism. The progeny of these animals were tested in a breeding experiment. At the time of the report, of 128 offspring, 98 had been proven to be resistant to infection. Other experiments are underway in an attempt to develop disease resistant strains in the various breeds.

Pucci records that the Zebu cow is immune to foot-and-mouth disease as is also the F₁ produced by the mating of Zebu to certain Italian and Swiss cattle. Assuming this to be true, this character, specific immunity to foot-and-mouth disease, theoretically should be possessed by certain individuals among modern herds, in the ancestry of which the Zebu is to be found.

Bonsoma has shown that Africander cattle are less susceptible to Rickettsiosis (Heart Water) than British beef breeds. Africander cattle when crossed with the common beef breeds results in individuals which possess natural resistance to Rickettsiosis.

**Parasitism**

Although in the field of parasitism, Gregory, Miller, and Stewart have presented some interesting evidence showing that sheep vary in resistance and susceptibility to stomach worms (*Ostertagia circumcincta*) infection. They found that the Romney breed was more resistant while other breeds were more susceptible. They also found that there was considerable variation of infection resistance in the other breeds. By experimental breeding
to produce resistant sheep, the investiga-
tors have concluded that genetic selection
should effectively change the degree of
resistance or susceptibility in populations
of sheep.

Also in the field of parasitism, in the
case of sheep, it is known that Cheviot
sheep are more resistant to *Hemonchus con-
tortus* infection than breeds of sheep
originating from the lowlands.

Resistance and susceptibility of cattle to
*B oophilus annulatus microplus* (Cattle Fever Tick) were studied, using a group
of 171 animals of European, Indian, and
native breeds in four localities in Brazil.
Indian and native cattle were found to be
highly resistant, having 4.7 to 6.7 per
cent infestation, respectively. European
cattle were found to be highly susceptible
with an average infestation of 88.5 per
cent. *B. a. microplus* did not develop on
Indian and native cattle as quickly as on
European cattle. The Aberdeen Angus,
Fresian and Flemish breeds were the most
susceptible and the Brown Swiss the most
resistant of the European breeds studied.

**Equine Susceptibility Variations**

Lambert, Spellman, and Osborn some
years ago indicated the existence of gen-
etic differences in horses in regard to their
susceptibility to encephalomyelitis. It is
possible that this factor may lead to selec-
tive breeding as a method of control of
this disease.

The success achieved in the breeding of
plants possessing a high degree of resis-
tance to disease is most noteworthy.
Because of the economic factor, it is not
practical to treat diseases of plants on a
large scale. In poultry a similar condition
exists considering the relatively low value
of the individual bird. It seems logical
to develop strains of poultry resistant to
several of the more important avian dis-
eas. In the case of swine diseases, con-
trast of hog cholera, brucellosis, and swine
erysipelas might well be attempted by
this method.

With regard to the large domestic ani-
mal breeders are of the opinion that the
process by which it will be possible to
breed animals possessing a higher degree
of resistance to diseases prevalent in cer-
tain areas, will be too slow and too ex-
pen sive for general adoption. This would
most certainly be the case for the indi-
vidual stockman, but when considering
the situation with a long range view, it
might be quite economical for a purebred
breeding association or government agency
develop resistant strains of animals for
general distribution.

The veterinarian may well recognize
and consider the practice of this method
of preserving the health of animals as one
of his responsibilities.

**REFERENCES**

1. Barrison, V. J. Contributions to the study of
genetic resistance and susceptibility of cattle to
1941.
2. Beavers, C. E., McClary, C. F., and Miller, M. W.,
The results of eight years' selection for disease
resistance and susceptibility in White Leghorns.
3. Bensma, J. C., Hereditary heart water-resistant
4. Boyed, M. F., Resistance of sheep to stomach
5. Cameron, H. S., Hughes, E. H., and Gregory, P. W.
Genetic resistance to brucellosis in swine. Jr. of
6. DeVoll, H. M., Quigley, G. D., and Byerly, T. C.
Studies of resistance to pullorosis disease in chick-
An analysis of environmental and genetic factors
influencing stomach-worm infestation in sheep.
Jr. of Gen. 29:391-400. 1940.
8. Gowen, J. W., and Calhoun, M. L. Factors affect-
ing genetic resistance of mice to mouse typhoid
caused by *Salmonella typhi*. Jr. of Inf. Diseases
73:40-56. 1941.
Breeding for resistance to fowl typhoid in poultry.
Rept. on Ag. Res., Iowa Ag. Exp. Sta. 176. 1943.
10. Hetzer, H. O. The genetic basis for resistance and
susceptibility to *Salmonella. avutrce* in mice.
11. Hill, A. B. The inheritance of resistance to bac-
generations of fowls bred for resistance to neo-
13. Hutt, F. B. Breeding strains of poultry resistant
duction of mortality in fowls by breeding. Proc.
7th World's Poult. Cong. 49:51. 1939.
swine for natural resistance to cholera. 1929.
17. Lush, J. L. Application of genetics to animal
19. Roberts, E. Breeding swine for resistance to hog
20. Scott, R. G. The inheritance of resistance to
*Salmonella. avutrce* in various strains of mice.
21. Ward, A. H. Inheritance of susceptibility to severe
22. Webster, L. T. Inherited and acquired factors in
resistance to infection. Jr. of Exp. Med. 7:793-
843. 1935.
23. Weir, J. A. Genetic resistance of mice to live and
heat-killed *Salmonella. typhi* in mice. M.S. thesis.
Ames, Iowa State College Library. 1942.
24. Zeile, M. R. Genetic constitution of host and
71:131-153. 1940.