



PENN STATE

**POULTRY POINTERS**

POULTRY SCIENCE • CAPITAL REGION • VETERINARY SCIENCE  
FOOD SCIENCE • AGRICULTURAL ECONOMICS • AGRICULTURAL  
& BIOLOGICAL ENGINEERING • ENTOMOLOGY

**CHAOS, CERTAINTY  
AND CHICKENS**  
Dr. William B. Roush  
Associate Professor  
Poultry Science

When the word "chaos" is mentioned, usually the picture that comes to mind is complete disorder and utter confusion.

In the past 20 years, a new science has been developed by physicists and mathematicians which gives a new meaning for chaos.

The mathematical definition of chaos is random behavior in an ordered system. That is, the results of research in the area of physics and mathematics show cases where some responses which appear to be random can be shown to have order.

The phenomenon of chaos was found by Edward Lorenz, a meteorologist. In 1960, Lorenz was examining a computer model

of a simple weather system. He found something strange. While inadvertently putting numbers in the program that differed only by less than one part per thousand, he discovered that the resulting weather projections soon diverged farther and farther until they bore no discernible relation to each other.

With this simple model and primitive computer equipment, he had discovered that systems which are described by nonlinear equations can be extremely sensitive to small changes, often resulting in "chaotic" behavior. Linear systems, on the other hand, are more robust in that small differences in initial conditions lead only to small differences in the final result.

Robert May, a theoretical biologist, wrote a paper in 1976 that is now a classic in chaos theory. He gave an example of a simple equation used to study population

growth. The equation is  $X' = AX(1-X)$ , where  $X'$  is the population for one year,  $X$  is the population of the preceding year, and  $A$  is a parameter that varies between 0 and 4.

To examine chaos theory, here is something you can try with your calculator. Or, if you have a computer you might try the following BASIC program:

```
10 INPUT A
20 X = .3
30 FOR I = 1 TO 150
40 X = A*X*(1-X)
50 PRINT X
60 NEXT I
70 END
```

To make things simple, suppose  $X$  and  $X'$  are numbers between 0 and 1 with the true population a million times these values. Suppose the population ( $X$ ) is .3 (ie - 300,000) and  $A = .2$ . Plugging in the numbers  $2(.3)(.7)$ , you get .42. To obtain the next year's population plug .42 (this is the new  $X$  or old  $X'$ ) into the formula  $2(.42)(.58)$  or approximately .4872. Using the same procedure, three years and thereafter, the population stabilizes at .5. In fact, whatever the original population size, the population will stabilize at .5. If  $A$  is increased to 2.6 the population eventually stabilizes at, approximately, .62.

Now increase the value for  $A$  to 3.2. The population no longer stabilizes to one number, but eventually alters between two values, approximately .5 and .8. As you raise the value of  $A$  to 3.5 the numbers alter between four numbers, approximately .38, .83, .5, and .88. Increasing the  $A$  value a little more causes an alteration between eight numbers. The doubling of the number of values continues as the value for  $A$  is increased.

Then suddenly, at approximately  $A = 3.57$ , the number of values grows to infinity the population goes into "chaos." The effect is very apparent if it is graphed. All this from the seemingly simple equation  $AX(1-X)$ .

An interesting attribute of this equation is that there is a paradox to this chaotic behavior. Although the responses appear chaotic over a certain time period, if the responses are plotted as one time period against another time period ( $X$  versus  $X'$ ), a form or structure for the responses becomes apparent.

The discovery of the mathematics of chaos dispels an illusion that mathematics is always certain. In science there is always the goal to define biological organisms and their surroundings in a certain, accurate, and precise manner. While in certain controlled situations mathematics can define out-

comes precisely, attempts to model nature and its factors are more complex and variable.

The results of chaos and the behavior of nonlinear systems have implications in a number of fields such as physiology, chemistry, and economics. For example, it has been shown that physiological systems, including the hormone system, heart rhythms, and breathing can exhibit chaotic behavior under certain circumstances.

So what does this have to do with chickens? It so happens that the equation illustrated by May in 1976 is very similar to an equation used to describe growth in animals. This observation has led to studies at Penn State with broiler chickens that have shown that day-to-day growth rate shows evidence of chaotic responses (random but ordered values). These mathematical studies with poultry may give insight into the control of disease conditions such as ascites which are associated with increased growth rate.

For more information on the mathematics of chaos, the books "Chaos: Making A New Science" by James Gleick and "Does God Play Dice: The Mathematics Of Chaos" by Ian Stewart are suggested. Both of these can be obtained from or ordered at your local bookstore.

**ATTN: AGRICULTURAL & INDUST.**

**DIESEL EQUIP. OWNERS**  
HAVING DIESEL ENGINE PROBLEMS?  
CONTACT MILLER DIESEL INC.  
FOR COMPLETE AUTHORIZED



FUEL INJECTION  
SALES & SERVICE.  
EXCHANGE UNITS ALSO  
AVAILABLE FOR PUMPS,  
INJECTORS AND  
TURBOS.

For Further Information, write/call:

**MILLER DIESEL INC.**

DIESEL FUEL INJECTION & TURBO CHARGER SPECIALIST  
6030 Jonestown Rd., Harrisburg, Pa. 17112  
1-800-296-3931 Interstate 81 Exit 26

**MILLER PRO**



**Hydraulically Adjustable Rotary Rake**

- Exclusive patented hydraulic raking height adjustment
- 11 Cam action tine arms gently lift and release crop with no roping and minimum leaf loss
- Rakes fluffy windrows for less drying time
- Model 1100 rakes 10'6" swath for 13'5" working width
- Fully enclosed gearbox for protection from chaff
- Swath curtain bolted to steel frame
- Tandem axle optional



**Hydraulically Driven & Adjustable Twin Rotary Rakes**

- Model 2200 rakes to one side
- Model 2200C rakes to middle
- Hydraulically steered swing frame doubles as oil reservoir
- Working width up to 22 feet plus windrow
- Rakes may be used separately
- Designed and built in the USA

Miller Pro Retail Financing  
Great rates and broad payment options

**1-800-247-5557**

**MILLER  
ST. NAZIANZ**

Profit Making Products for the Professional Farmer

**Keep them simple,  
we did.**

**Belarus**

Sensible  
Down-To-Earth  
Tractors



If you're looking for a small tractor that gets you through tough spots, you'll like the new 4-wheel drive Belarus 310.

It's a simple, economical 36-hp tractor with the 4-wheel advantage that gives you extra traction on rough, wet ground. You'll like the fuel efficiency and low maintenance of the 310. And its low price is another real advantage. Stop in and see us for all your farm equipment needs and take a look at the Belarus 310.

**NEW YORK**

**BROWN'S  
TRACTOR  
& EQUIPMENT  
SERVICE, INC.**

RR 2, Box 11B,  
Jackson Hill Rd.  
Bonnville, NY

**MARYLAND**

**SCHROCK  
FARM EQUIPMENT**

Route 1, Box 2568  
Oakland, MD  
301-334-9060

**PENNSYLVANIA**

**ROVENDALE AG  
& BARN EQUIPMENT**

RD 2, Box 210  
Watsonstown, PA  
717-538-9564

**ANDERSON  
TRACTOR SALES**

1415 Main St.  
Jacobus, PA 17407  
1-800-457-5705

**LUBINIECKI  
WELDING**

**& EQUIPMENT**

RD 2, Box 160  
Meadville, PA

**MARSHALL  
MACHINERY, INC.**

Route 652, RR 4  
Honesdale, PA

**VIRGINIA**

**BEVERAGE  
TRACTOR**

Rt. 340 South  
Stuarts Draft, VA  
800-296-3325

**STARKEY  
FARM CO.**

Rt. 213, PO Box 250  
Galena, Md.



Sensible, Down-To-Earth Tractors