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Detection of Anthelmintics Resistant Nematodes in Sheep Flocks Using Artificial Neural Networks

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Abstract- Anthelmintic resistance is an important problem in most sheep-producing countries of the world. Studies in this field are performed by clinical tests. Identification of anthelmintic resistant nematodes without clinical test can help farmers to save money and time; on the other hand it can help them to avoid inefficient treatment and probable outcomes. In this study a multilayered neural network has been proposed to detect anthelmintics resistance nematodes in sheep flocks.

Key- words: Anthelmintic resistance, FECRT test, Feed forward ANN, Modeling

1 Introduction

Using Anthelmintics (AH) is the main method to control of gastrointestinal nematode infections of sheep. Development of anthelmintic resistant nematodes can threaten the sustainability of this control tool. Anthelmintic resistance (AR) is an important problem in most sheep-producing countries of the world [1]. Studies in this field are performed by taking faecal samples of a number of sheep flocks and then using in vitro techniques [2]. It is important to diagnose the anthelmintic resistance in flocks and find the rate of this phenomenon in sheep flocks in any country. Sustainability of utilizing of AH needs correct and reliable information on the effectiveness of the different drug families. Usual procedure to detect the efficiency of a drug is clinical observations. One of the conventional anthelmintics in the world is Benzimidazole (BZD) and determining BZD resistant nematodes is crucial. The clinical method for this task presently is faecal egg count reduction test (FECRT) in a sample of sheep flocks [3]. Identification of BZD resistant nematodes without clinical test can help farmers to save money and time; on the other hand it can help them to avoid inefficient treatment and probable outcomes.

Artificial neural networks (ANNs) as universal approximators [4] can be employed for modeling the natural behaviors. Also ANNs can be used for data classification [5] and inference tasks in any imperial science [6]. Because of above mentioned advantages ANNs have been frequently employed in medical applications (for example the reader can refer to [7-10]).

In this paper we will develop an ANN system for identification of BZD resistance nematodes without clinical tests. That is, we will try to guess that if a flock will reply to Benzimidazole treatment or not. In part 2 of this paper the technique of data gathering is represented; In Part 3 construction of artificial neural network for AR detection is explained and finally part 4 includes the conclusions.

2 Sampling Method

The data utilized in this paper is obtained through a procedure used to detect AH resistant nematodes called faecal egg count reduction test (FECRT), that is suggested by the World Association for the Advancement of Veterinary Parasitology (WAAVP) [11].

2.1 FECRT Test

For doing FECRT we must be sure that none of the under experience animals received any AH treatment for at least 8 weeks before starting of the tests. In each flock faecal samples from *N* sheep that are older than 6 months of age are taken.

Then McMaster technique [12], in which one counted egg equals 50 eggs per gram of faeces (EPG), is employed to test the samples. Animals with more than 150 EPG of trichoetrongyle nematodes are randomly distributed into two groups with equal associates. The drug albendazole is orally treated for animals in group 1 at 5 mg/kg body weight [13], but group 2 stay untreated and considered as control proup. In every sampled flock, animals are kept inside a pen for a period of 16 hours prior to treatment. Animals are refrained from any food for the interval of this imprisonment period. In the next step, the pooling of faecal samples of both treated and control groups are cultured for 7 days at ambient temperature to generate thetrichostronogyle infective larvae. After that, larvae are must be collected to perform the identification of larvae for each bulk culture [14].

Ten days after organization of AH treatment, individual faecal samples must be taken from all the animals, then faecal egg counts (FEC) must be performed on samples via a modified McMaster technique. The arithmetic mean FEC of each treatment group (EPGt) is determined and compared to that of the control group (EPGc) from the same flock. Percentage reduction (R%) is determined by:

$$R\% = (1 - \frac{EPG_t}{EPG_c}) \times 100 \qquad (1)$$

According to the WAAVP guidelines, one of criterions of resistance is that R% be more than 98% [11]. If this criteria is fulfilled the flock can be considered suspect for benzimidazole resistance.

2.2 Data Gathering

A survey must be performed among the flocks at the time of the second faecal sampling. The following information is required:

- Infective larvae that are include Haemonchus (H), Trichostrongylus (T) and Oesophagostmun (F) larvae.
- Percentage reduction of EPG.

Table 1 shows the percentage of infective larvae found in the treated and control groups for a test that performed in Mexico as well as the R% and status of resistance or susceptibly [11].

Flock No.	Control (%)			Treated (%)			EPG reduction	Status
	H	**T**	**O**	**H**	**T**	**O**		
1	62	22	16	100	0	0	98	S
2	72	0	28	73	27	0	98	S
3	70	14	16	100	0	0	94	R
4	70	16	14	100	0	0	71	R
5	68	28	4	100	0	0	92	R
6	100	0	0	100	0	0	90	R
7	78	22	0	100	0	0	100	S
8	86	14	0	73	27	0	100	S
9	84	4	12	50	50	0	100	S
10	92	6	2	NL	NL	NL	97	R
11	86.66	6.66	6.68	100	0	0	96	R
12	82.35	11.76	5.89	NL	NL	NL	97	R
13	59.52	40.48	0	0	100	0	100	S
14	90.47	9.53	0	100	0	0	94	R
15	63.04	17.39	19.57	NL	NL	NL	100	S
16	84	0	16	100	0	0	100	S
17	64	20	16	67	33	0	99	S
18	92.3	0	7.7	NL	NL	NL	100	S
19	76	24	0	NL	NL	NL	99	S
20	86	4	10	100	0	0	97	R
21	76.19	19.04	4.77	100	0	0	98	S
22	62	20	18	NL	NL	NL	99	S
23	78	22	0	NL	NL	NL	98	S
24	84.78	0	15.22	100	0	0	99	S
25	72.5	22.5	5	NL	NL	NL	99	S
26	76	0	24	NL	NL	NL	99	S
27	56	16	28	NL	NL	NL	99	S
28	72.41	27.59	0	100	0	0	99	S
29	64	24	12	67	33	0	99	S
30	78	20	2	100	0	0	96	R
31	83.33	5.55	11.12	NL	NL	NL	99	S
32	92	8	0	100	0	0	99	S
33	64	24	12	NL	NL	NL	98	S
34	66	24	10	100	0	0	98	S
35	62	12	26	60	40	0	99	S
36	72	22	6	100	0	0	100	S
37	65.21	34.79	0	NL	NL	NL	99	S
38	86	4	10	100	0	0	93	R

Table 1. Infective larvae found in the treated and control groups as well as the R% and status of resistance or susceptibly.
S: susceptible, **R**: Resistant, **NL**: no larvae found
H: Haemonchus, **T**: Trichostrongylus, **O**: Oseghagostomum

3 An ANN for Detection of AR Nematodes

3.1 Multilayered feed forward network

A feed-forward network has a layered structure. Each layer consists of units which receive their input from units from a layer directly below and

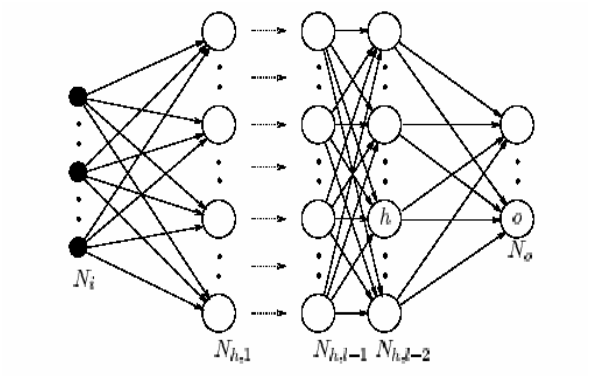

Fig. 1. A multilayer feed forward neural network

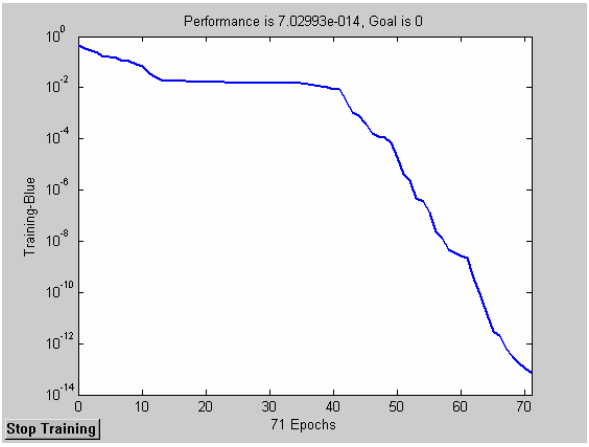

Fig. 2. Decrease of learning error for about 70 epochs

send their output to units in a layer directly above the unit. There are no connections within a layer. The N_i inputs are fed into the first layer of $N_{h,1}$ hidden units. The input units are merely `fan-out' units; no processing takes place in these units. The activation of a hidden unit is a function F_i of the weighted inputs plus a bias, as given in:

$$y_k(t+1) = F_k(s_k(t)) = F_k\left(\sum_j w_{jk}(t) y_j(t) + \theta_k(t)\right) \quad (2)$$

The output of the hidden units is distributed over the next layer of $N_{h,2}$ hidden units, until the last layer of hidden units, of which the outputs are fed into a layer of No output units (see figure 1).

It has been shown [4, 15, 16] that only one layer of hidden units sauces to approximate any function with finitely many discontinuities to arbitrary precision, provided the activation functions of the hidden units are non-linear (the universal approximation theorem). In most applications a feed-forward network with a single layer of hidden units is used with a sigmoid activation function for the units.

Also a one layered network is a universal approximator, but it is crucial how to adjust the weights from input to hidden units. An answer to this question was presented in [18]. The central idea behind this solution is that the errors for the units of the hidden layer are determined by back-propagating the errors of the units of the output layer. For this reason the method is often called the back-propagation learning rule. Back-propagation can also be considered as a generalization of the delta rule for non-linear activation functions1 and multi-layer networks.

3.2 An ANN for Detection of AR Nematodes

In this work, we employed a one hidden layered network to construct a structure for identifying of the BZD resistant nematodes. The network has 3 nodes in input layer (N_i=3) that are the percentage of infective larvae (H, T and O) found in the control group – that do not need any treatment on animals- and one node in out put layer that its target was set to 0 for BZD resistant nematodes and 1 for susceptible nematodes. There are 4 neurons in hidden layer of network and sigmoid activation functions were used.

For training the network, the data of flocks 1 to 34 in table 1 were selected as training data and back-propagation learning rule was employed to adjust the weights of network. The decrease of learning error for about 70 epochs is showed in figure 2.

Flock No.	Clinical status	Network target	Network output	Error
35	S	1	1.0000	0.0001
36	S	1	0.9488	0.0012
37	S	1	1.0000	0.0000
38	R	0	0.0000	0.0003

Table 2. Network target and network output for validation data.

The data corresponding flocks 35 to 38 were considered as validation data. The output of trained network and clinical results for this set of data has been rearranged in table 2. It is clear from table 2 that the network output is 0 when the flock had BZD resistant nematodes in clinical tests and network output is 1 when the flock had BZD resistant nematodes in clinical tests.

4 Conclusions

In this study a multilayered neural network has been proposed to detect anthelmintics resistance nematodes in sheep flocks. This can help farmers on the entire world to predict that if their flock will reply to specific anthelmintics or not, without clinical tests. It may cause to save money and time in animal husbandries; on the other hand it can help veterinary surgeons to avoid inefficient treatment and probable outcomes.

Although the proposed method was illustrated for one type of anthelmintics (i.e. albendazole) in the particular region as a typical case, but the technique is general and can be employed in all of the anthelmintic resistance studying cases.

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