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Simulation of infestation risk of cattle by gastro-intestinal trichostrongylids in a tropical humid climate

AUMONT (G.). Simulation du risque d'infestation de bovins par des trichostrongylides dans un climat tropical humide. *Revue Élev. Méd. vét. Pays trop.*, 1993, **46** (1-2) : 23-26

La dynamique des populations de larves de trichostrongylides du troisième stade (L3) autour des bouses de bovins a été ajustée avec des modèles non-linéaires (loi marginale) dans un climat tropical humide dans des situations climatiques différentes. Ces modèles marginaux ont été combinés avec la durée de survie des bouses, le poids des animaux, le nombre de bouses par vache et par jour, la charge en animaux par hectare et la masse d'herbage disponible, en tenant compte de la tendance des bovins à paître de façon inégale, afin d'estimer la probabilité d'infestation par des larves L3. Le risque d'infestation a été calculé pour différents âges de repousse de l'herbage et différents temps de pâture dans des système de rotation des pâturages. Le risque d'infestation variait entre 0 et 1400 L3 par kg de matière sèche d'herbe et par jour, dépendante de la loi marginale. Le temps de pâture, l'âge de la repousse et la disponibilité de fourrage étaient les principaux facteurs de variation du risque d'infestation.

Mots clés : Bovin - *Trichostrongylidae* - Infestation - Herbage - Pâturage en rotation - Intensité de charge - Zone tropicale.

INTRODUCTION

Cattle are mostly reared on pasture in tropical countries. Gastro-intestinal parasitism is commonly involved as a major limiting factor of performances of these pasture systems (5, 9). To our knowledge, no epidemiologic model exists to predict infestation risk by trichostrongylids for cattle reared in tropical pastures according to different pasture management systems. In Guadeloupe (French West Indies), worm populations of cattle are mostly composed of trichostrongylids (*Haemonchus* sp., *Trichostrongylus* sp., *Cooperia* sp.) as in many other tropical countries with humid climates. These parasites induce a decrease of 8 % in calf growth from birth to weaning even with small internal populations (3). The improvement of pasture systems requires a good knowledge of third stage infective larvae (L3) dynamics to fit both parasitism control methods and grazing systems. In a humid climate, even with a marked dry season, livestock management factors were shown to be decisive for the L3 population on pasture (4, 8) and worm populations in calves and cows (3). Day to day variations in relative humidity, temperature and global radiation are low in West Indies. In such conditions, in Guadeloupe, AUMONT et al. (2) showed that there are poor relationships between climatic conditions and the L3 population size on pasture. The objectives of this study were, a) to contribute to a definition of infestation risk by trichostrongylids in cattle-grazing tropical pastures and, b) to determine this infestation risk for different cattle-grazing tropical systems in a tropical humid climate of the West Indies. A numerical approach was used to simulate different livestock management systems, involving the survival duration of pats, the body weight of cows, the number of pats per cow and per day, the stocking rate, the herbage mass availability, the age of herbage regrowth and the grazing time.

MATERIAL AND METHODS

The basic data were third stage larvae population kinetics on herbage around pats after experimental pat deposition, that were described by AUMONT et al. (2). These kinetics (S) were fitted by the following model :

$$S(t) = MG(t)D(t) \qquad (a)$$

where

$$G(t) = (1+ \Phi\exp((t-\alpha)/\beta)^{**}(-1/\Phi)\ G(t) \qquad (b)$$

$$D(t) = \exp(-\mu t^{2}) \qquad (c)$$

G(t) represents the growing population stage and D(t) represents the mortality population stage. Φ, α, β, μ are the parameters of the model determined by non linear regression procedures. t is the time in days (d). M is the potential maximal size of the L3 population.

Three different dynamics of L3 population size expressed in L3/kg dry matter of grass (DM) were chosen because they were representative of situations prevailing in tropical grazing systems for cattle i.e. either an unimodal evolution of L3 population size with a maximum ranging from 16 days after pat deposition (situation 1) to 25 days after pat deposition (situation 2), or a bimodal evolution of L3 population size (situation 3). These kinetics are shown in figure 1.

Parasitism risk was defined as the probability of contact between animal and L3. However, the chosen unit was the number of L3 per kg DM to present interpretable data

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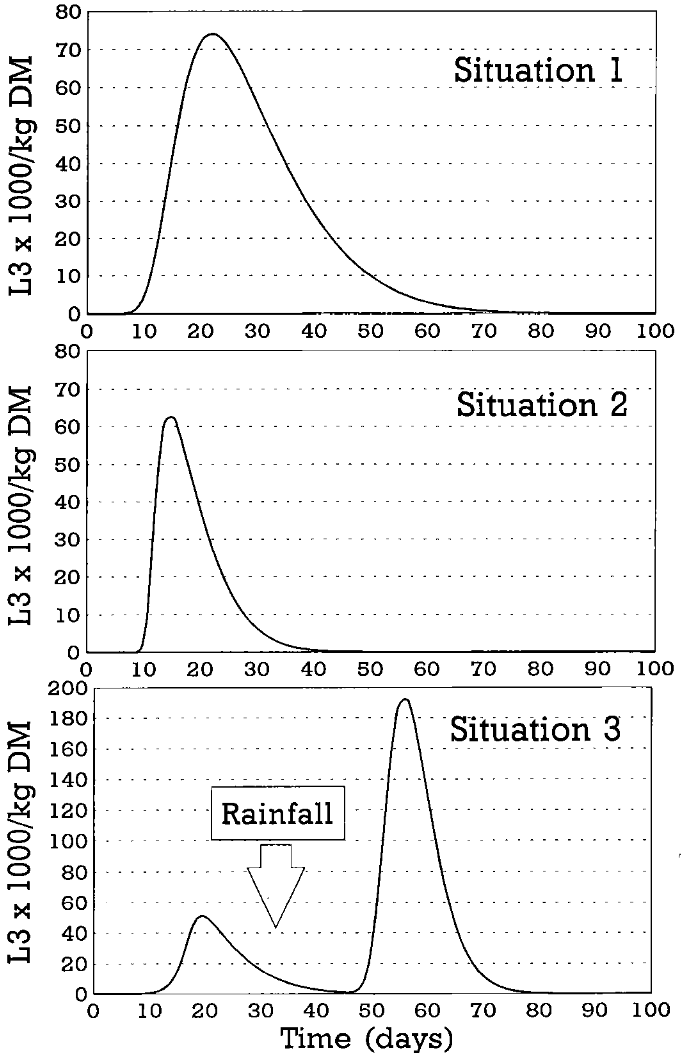

Figure 1 : Kinetics of L3 abundance (L3 x 1000/kg DM) on herbage around pats after pats deposition. Situation 1, 2 and 3 refer to the most frequent L3 kinetics that were recorded in Guadeloupe (2).

for forage scientists. The probability of grazing near pats (PG) for a fixed forage availability was defined by the following formulae :

$$PG(w) = 1 - S^{w} \qquad (d)$$

where

$$S(r,n,d) = 1 - (\pi r^{2} nd/10\,000) \qquad (e)$$

$$w = SR/Bc \qquad (f)$$

where r is the radius of pats and contaminated areas around (in meters), n is the number of pats per day and per cow, d is the survival duration time (in d), SR is the stocking rate (kg/ha), and Bc is the average bodyweight (BW) of cows (kg). S represents the part of paddock free of pats. w represents the number of cows per ha.

The PG was dependant on forage availability according to the following formula :

$$PG(\partial) = 1 - \exp(\partial t) \qquad (g)$$

where t was the time in d after the entrance in a paddock and ∂ was expressed in d^{-1}.

Finally the infestation risk (R) was defined as the following formula :

$$R = \sum_{i=0}^{i=n-1} \left(\int_{t=ia}^{t=s+ia} M*g(t)D(t)*PG(\partial)*PG(w)dt)/s \right)(s+a)/d \qquad (g)$$

where a was the age of herbage regrowth (d), s was the grazing time (d) and n was the integer part of survival duration time divided by s+a. s+ia could never be superior to d.

In the results presented, d was fixed to 75 days (2), the Bc to 350 kg (body weight of local creole cows), the stocking rate to 1500 kg BW/ha and ∂ to 0.65 d^{-1}. The simulation was carried out for time of grazing ranging from 2 to 30 days and for age of regrowth ranging from 10 to 60 days.

RESULTS AND DISCUSSION

Our model was based on the hypothesis that infestation risk when grazing far from the pats, was of minor importance in comparison to infestation risk when grazing near pats. As a matter of fact, L3 population size further than one meter radius from the pats was shown to be 100 to 1000 fold lower than L3 populations size around pats (2, 4). The probability of grazing near pats was an important criterion for the definition of infestation risk. It integrated the patchy grazing behaviour of cattle that was clearly described by JONES and RATCLIFF (6) on tropical pastures of Queensland. As well established, cattle refuse to graze around their pats particularly when the pats are fresh or when forage availability is great. That is the reason why the forage availability (and grazing time) and stocking rate were included in the formulae for the calculation of the probability of grazing near pats. This model was similar to that built for predicting grazing time by herbage intake and/or herbage availability of ALLDEN and McD WHITTAKER (1). The parameter ∂ used in our study was determined from experimental data of MANTEAUX et al. (7) on DM intake of cows on Guadeloupean pastures.

When time of pat deposition was increased by simulation, the maximum of L3 population size around pats decreased and the time of this maximum decreased. Similar results could be recorded even with bimodal L3 kinetics such as that of situation 3 (fig. 2). This phenomenon was

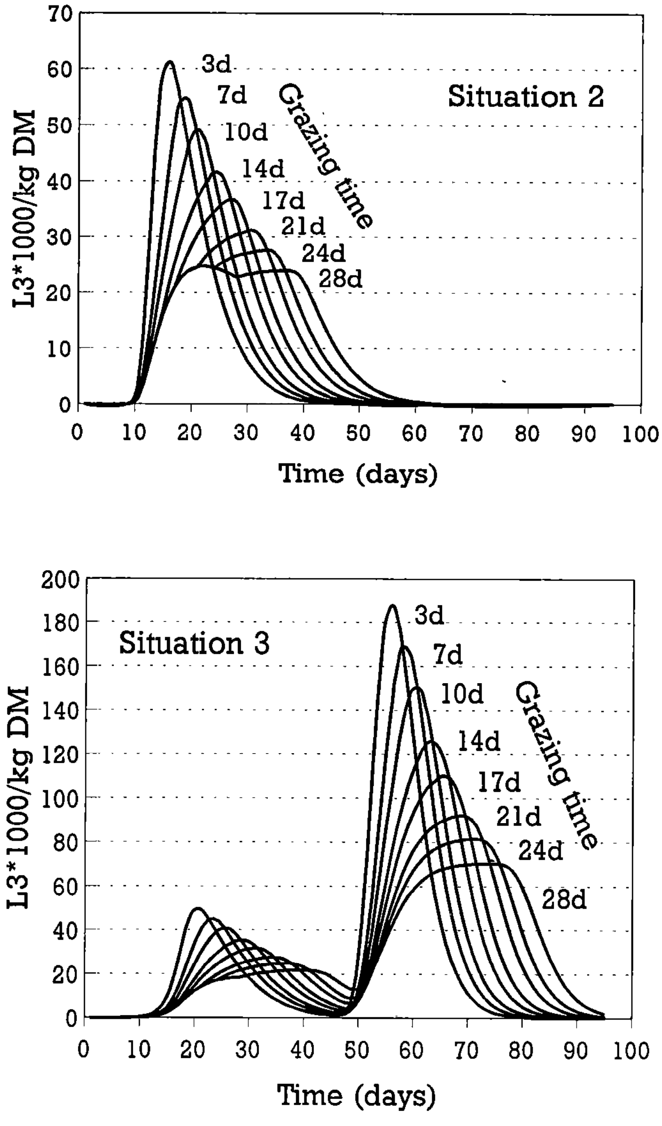

Figure 2 : Kinetics of L3 abundance on herbage around pats for different grazing time. Situations 2 and 3 refer to the most frequent L3 kinetics that were recorded in Guadeloupe (2).

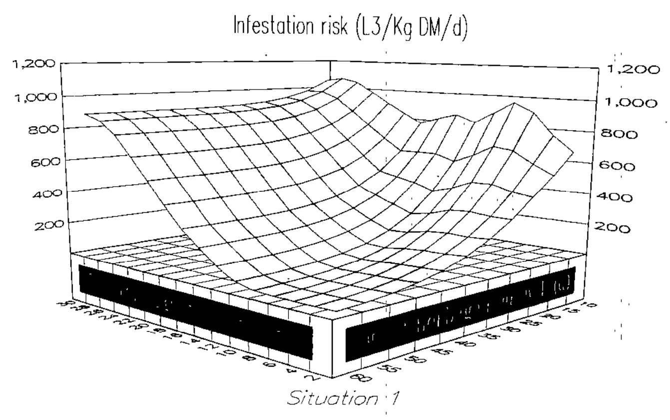

Figure 3 : Infestation risk by trichostrongylids for grazing cattle on tropical pasture according to age of herbage regrowth and grazing time. Situation 1 : unimodal L3 kinetic (maximum at the 25th day) after experimental pat deposition.

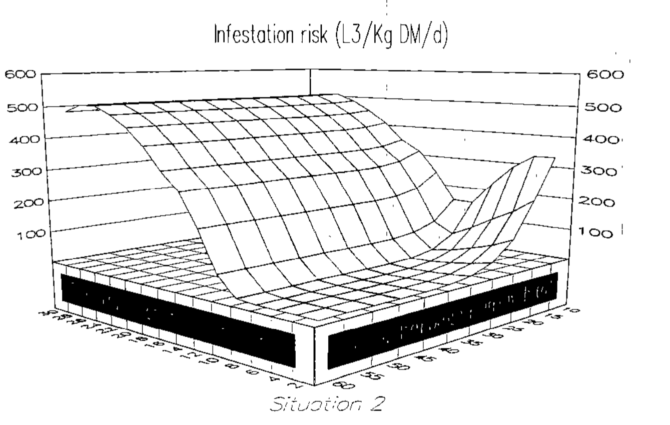

Figure 4 : Infestation risk by trichostrongylids for grazing cattle on tropical pasture according to age of herbage regrowth and grazing time. Situation 2 : unimodal L3 kinetic (maximum at the 16th day) after experimental pat deposition.

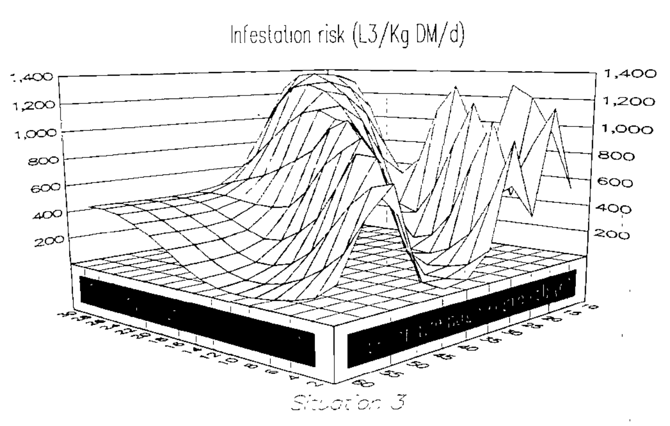

Figure 5 : Infestation risk by trichostrongylids for grazing cattle on tropical pasture according to age of herbage regrowth and grazing time. Situation 3 : bimodal L3 kinetic (maximum at the 20th and the 56th day) after experimental pat deposition.

due to the spacing of pat deposition and to the fact that L3 abundance around pats was defined as the means of L3 density around different pats of different ages.

The infestation risks are shown for the 3 situations by surface responses according to grazing time variations (2 to 30 days) and age of herbage regrowth variations (10 to 60 days). The infestation risks ranged from 0 to 1400 L3/kg DM (fig. 3, 4, 5). A decrease in the age of herbage regrowth and the increase in the grazing time induced a dramatic increase of the infestation risk. A minimum in the infestation risks shown as a “valley “ in figures, existed for grazing time lower than 8 d and age of herbage regrowth of 35 d. However, when bimodal evolution of L3 population size occurred after an important rainfall for example (fig. 4), the surface of L3 infestation risk became chaotic. In such a situation, the infestation risk with a rotational system might be higher than that with continuous grazing. This study confirmed that in cattle grazing pastures of tropical humid climates, the pasture management system represents the main sources of variation in infestation risks.

These results showed that simulation approach might give consistent results in prediction of infestation risk of cattle by trichostongylids. Other hypotheses on parameters of the model could be used to set up its utilization for a great variety of situations in tropical grazing systems. However, further epidemiological studies are required to confirm simulation results. They will help to improve simulations by including the variation of eggs density in excreted pats and the frequency of bimodal or trimodal L3 kinetics in the model. Simulations in cattle appeared as relatively simple despite their particular grazing behaviour, because L3 kinetics are easy to modelize. In contrast, similar simulations for small ruminants would be more complex because in these species, a) L3 kinetics greatly vary with the climatic conditions, b) between parasite species differences exist in L3 reaction to micro-climatic conditions and c) great variations exist in egg density of faeces. Such studies are now carried out in our laboratory.

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The population dynamics of trichostrongylid third stage larvae (L3) around bovine dung were fitted with non-linear models (marginal law) in a tropical humid climate in different climatic situations. These marginal models were combined with the survival duration of pats, the weight of cows, the number of pats per cow and per day, the stocking rate and the herbage mass availability, taking into account the patchy grazing behaviour of cattle in order to estimate infestation probability of cattle by third stage larvae. The infestation risk was computed for different ages of herbage regrowth and grazing times in rotational grazing systems. The infestation risk was found to range between 0 to 1400 L3 per kg of dry matter of grass and per day depending on the marginal law. The grazing time, the age of herbage regrowth and the forage availability were the main factors of variation of the infestation risk.

Key words : Cattle - *Trichostrongylidae* - Infestation - Grassland - Rotational grazing - Stocking rate - Tropical area.

AUMONT (G.). Estimulación del riesgo de infestación por tricoestróngilos gastro-intestinales en ganado, bajo un clima tropical húmedo. *Revue Élev. Méd. vét. Pays trop.*, 1993, **46** (1-2) : 23-26

La dinámica de las poblaciones de larvas de tercer estadio (L3) de tricoestróngilos (activas alrededor de la boñiga de bovino), en un clima tropical húmedo, se estudió con modelos no lineares (ley marginal), bajo diferentes situaciones climáticas. Los modelos marginales se combinaron con la duración de la supervivencia de los parásitos, el peso de las vacas, la cantidad de parásitos por vaca y por día, el número de animales por hectárea, la capacidad de almacenamiento y la disponibilidad de forraje. El comportamiento gregario de las vacas se tomó en cuenta con el fin de estimar la probabilidad de infestación del ganado con el tercer estado larval. El riesgo de infestación se consideró en los diferentes estadios de crecimiento forrajero y para los tiempos de pastoreo en sistemas de pastoreo rotativo. Según la ley marginal, el riesgo de infestación se situó en un rango de 0 a 1400 L3 por kg de peso de materia seca de pasto, por día. El tiempo de pastoreo, el estado de crecimiento forrajero y la disponibilidad de forrage, fueron los principales factores de variación del riesgo de infestación.

Palabras claves : Bovino - *Trichostrongylidae* - Infestación - Pasto - Pastoreo rotacional - Intensidad de carga - Zona tropical.