

# Multiparasitism, Production and Economics in Domestic Animals in sub-Saharan West Africa

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Over the past ten years, an informal West African animal helminthosis network has developed (Box 1), with the aims of both improving livestock productivity through parasite control and, ultimately, increasing rural income. The network places a strong emphasis on building up local research capacity through scientific partnership. This article highlights recent findings from projects of the network.

## Epidemiology of Multiparasitism

An appropriate knowledge of the spectrum, pathogenicity and epidemiology of gastrointestinal nematodes (GINs) in livestock is a prerequisite for the proper understanding of their impact on productivity and the development of integrated control strategies. Postmortem surveys on a range of livestock have been undertaken in several

West African countries, using a common methodology. For these surveys, digestive tracts from local abattoirs, or from animals purchased on farms, were analysed monthly. The analyses included artificial digestion of mucosa to establish the parasite spectrum and burden. A postmortem survey of Gambian N'Dama cattle demonstrated that almost all animals carry GINs<sup>1</sup>. The worm burden follows a distinct seasonal pattern, with over 80% of the adult worms occurring during the rainy season (June–October). Such a distinct seasonality with a rainy season peak is observed in all those areas with one single rainy season and a mean annual rainfall <1200 mm. In more humid areas with bimodal rainfall patterns, the seasonality is much less pronounced, a fact that has important consequences for control strategies. Multiparasitism is a common feature in livestock in West Africa. Figure 1 shows cumulative frequencies (in % of host population) of multiparasitism in sheep and cattle at two different sites that were not subjected to mass treatment. Cattle seem to harbour higher parasite diversity than small ruminants. Multiparasitism is also influenced by geographical location and climate. More detailed analyses are planned to identify other influencing factors. Among the several species of helminths encountered in cattle<sup>1,2</sup>, the predominant species were *Haemonchus contortus*, *Cooperia* spp, *Oesophagostomum radiatum* and *Bunostomum phlebotomum*. Likewise, in sheep, *Trichostrongylus colubriformis* and *H. contortus* are the most important parasites, with similar prevalences across sites (Table 1). No difference in worm burden was found between different age groups of sheep. To date, studies have been undertaken for cattle<sup>1,3,6</sup>, goats<sup>4-7,14</sup>, donkeys (Ref. 8; D. Frei, pers. commun.) and horses (D. Frei, pers. commun.). Further post-mortem studies are continuing in Côte d'Ivoire, Guinea Conakry and Guinea Bissau.

Experimental studies have further evaluated the epidemiology of GINs in domestic animals. Kaufmann *et al.*<sup>9</sup>

### Box 1. West African Animal Helminthosis Network

In 1986, the Department of Veterinary Parasitology of the University of Berne (Switzerland) initiated a collaborative research project with the International Trypanotolerance Centre (ITC) (J. Kaufmann, M. Njie, R. Mattioli, P. Ankers) in The Gambia on gastrointestinal nematodes (GINs) in livestock. A research partnership then started with the Centre International de Recherches Développement sur l'Élevage en zone Subhumide (CIRDES) (L. Ouattara, A. Ouédraogo), Burkina Faso, where a helminthology unit was created, and the University of Dakar (J.L. Pangui, J. Belot), leading to studies in Senegal (M. Ndao) and Togo (B. Bonfoh, T. Kponmassi). Further studies were launched in Sierra Leone (M.L. Barrie), Guinea Conakry (S. Fofana) and Guinea Bissau. This 'network' was strengthened by collaboration with the Institute of Tropical Medicine (ITM) in Antwerp (V.S. Pandey), Belgium, the University of Neuchâtel (B. Betschart, K. Pfister, M. Diehl) and the Swiss Centre for International Agriculture (ZIL) (P. Itty). In 1994, research activities started in Côte d'Ivoire with the Laboratoire National d'Appui au Développement Agricole (LANADA) (A.E. N'Depo, L. Achi, C. Komoin, P. Kone) and the Centre Suisse de Recherches Scientifiques (CSRS) (K. Atindehou), which maintains a coordinating and training role.

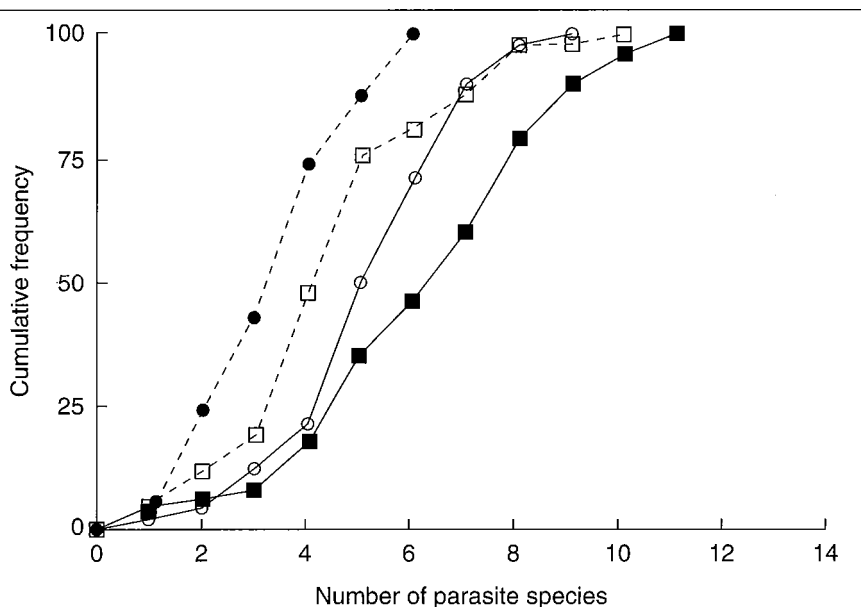


Fig. 1. Cumulative frequency (%) of multiparasitism in cattle (squares) and sheep (circles) in The Gambia (solid line) and Burkina Faso (dotted line). (Adapted from Refs 6 and 7.)

Table 1. Sheep gastrointestinal parasite spectrum, prevalence and average burden in several West African countries

Country	The Gambia		Burkina Faso		Senegal		Togo	
Annual rainfall in the study area (mm)	600–800		900–1000		350–750		1500	
Breed	Djallonké		Djallonké		Sahelian		Djallonké	
Sample size	52		42		51		56	
Study year	1990/91		1990/91		1990/91		1992	
Ref.	14		6		5		4	
Parasite	Prev <sup>a</sup> (%)	Aver	Prev (%)	Aver	Prev (%)	Aver	Prev (%)	Aver
<i>Haemonchus contortus</i>	67	137	69	225	88	731	80	404
<i>Trichostrongylus axei</i>					4	2		
<i>Trichostrongylus colubriformis</i>	98	2301	97	1329	78	634	90	286
<i>Cooperia curticei</i>	65	464	2	105	52	249	58	205
<i>Cooperia punctata</i>	12	175	5	117				
<i>Strongyloides papillosus</i>	50	211	2	15	90	264	64	136
<i>Gaigeria pachyscelis</i>	40	26	30	40	53	77	42	59
<i>Trichuris ovis</i>	4		2	15	49	15	3	23
<i>Skrijbinema</i>					5			
<i>Oesophagostomum columbianum</i>	85	24	38	40	72	234	39	69

<sup>a</sup>Abbreviations: Prev, prevalence; Aver, average.

demonstrated a substantial decrease in pasture contamination and increased calf growth if farmers moved the animals from their night holding places (correos) regularly during the rainy season (Fig. 2). In an analysis of a concomitant *H. contortus* and *Trypanosoma congolense* infection of N'Dama cattle, Kaufmann *et al.*<sup>10</sup> found an important pathological synergism between the two parasites. Because N'Dama cattle are naturally resistant to *Trypanosoma* infection, this result underlines the importance of GIN control to maintain the trypanotolerance of N'Dama cattle. Differential susceptibility to GIN between N'Dama and Zebu cattle showed that faecal egg counts were much lower in N'Dama cattle than in Zebu<sup>11</sup>. Therefore, N'Dama cattle seem to have not only a trypanotolerance trait but also a comparatively reduced susceptibility to GINs.

A series of experiments revealed that no, or only very few, reinfections occur during the dry season<sup>12–14</sup>. In the Sudano-Guinean climate, during the long dry season, *H. contortus* survives almost exclusively as hypobiotic larvae (arrested stage in the abomasal mucosa), whereas *Cooperia* spp and *O. radiatum* survive partly as hypometabolic adults with reduced fecundity and partly as larvae in both the gut lumen and nodules<sup>1,12,14</sup>. Pasture recontamination starts before the onset of the rains from resumed development of hypobiotic larvae. In more humid areas,

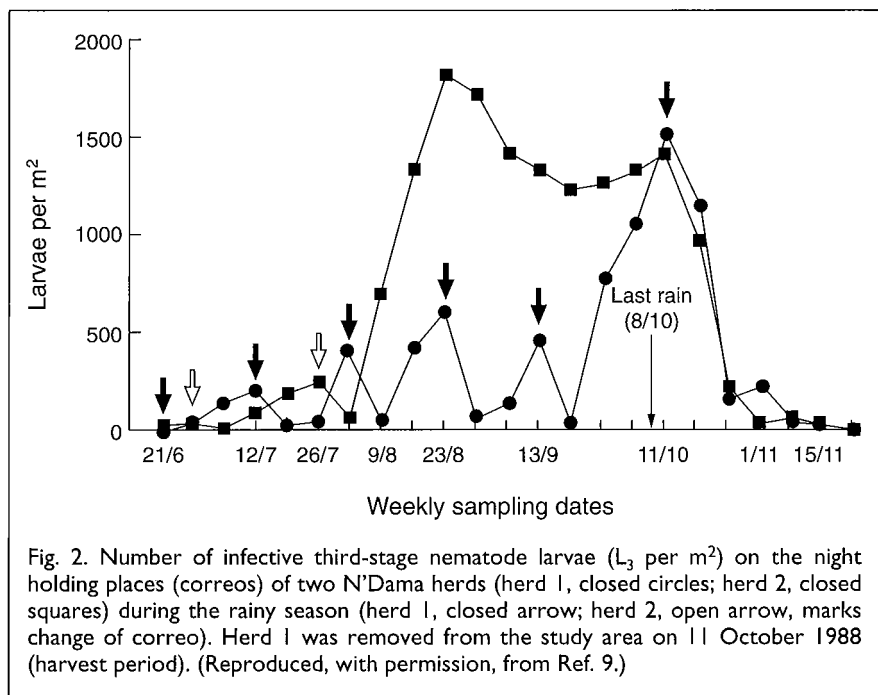


Fig. 2. Number of infective third-stage nematode larvae ( $L_3$  per  $m^2$ ) on the night holding places (correos) of two N'Dama herds (herd 1, closed circles; herd 2, closed squares) during the rainy season (herd 1, closed arrow; herd 2, open arrow, marks change of correo). Herd 1 was removed from the study area on 11 October 1988 (harvest period). (Reproduced, with permission, from Ref. 9.)

hypobiosis of *H. contortus* is much less frequent in small ruminants<sup>4</sup>.

### Productivity and Economics

In view of the above findings, a large-scale longitudinal study was designed to investigate the effects of a strategic treatment of GINs on productivity of N'Dama cattle and Djallonké sheep and to evaluate its economic impact in village systems in The Gambia (Fig. 3). In cattle, two annual fenbendazole

treatments (Panacur 7.5 mg  $kg^{-1}$  live-weight, Hoechst AG) improved live-weight by 8–17% in 1–4-year-old animals<sup>15</sup> (Fig. 4). Even a single treatment in the early dry season led to a significant weight gain<sup>12</sup>. The age at first calving decreased by eight months in twice-treated animals relative to their controls [50.2 months versus 58.3 months, respectively (product limit estimates of 25% quantiles)]. Furthermore, the same treatment schedule led to an annual calving rate of 52.2% in twice-treated



Fig. 3. Weighing N'Dama cattle in traditional herds in The Gambia (photograph, J. Zinsstag).

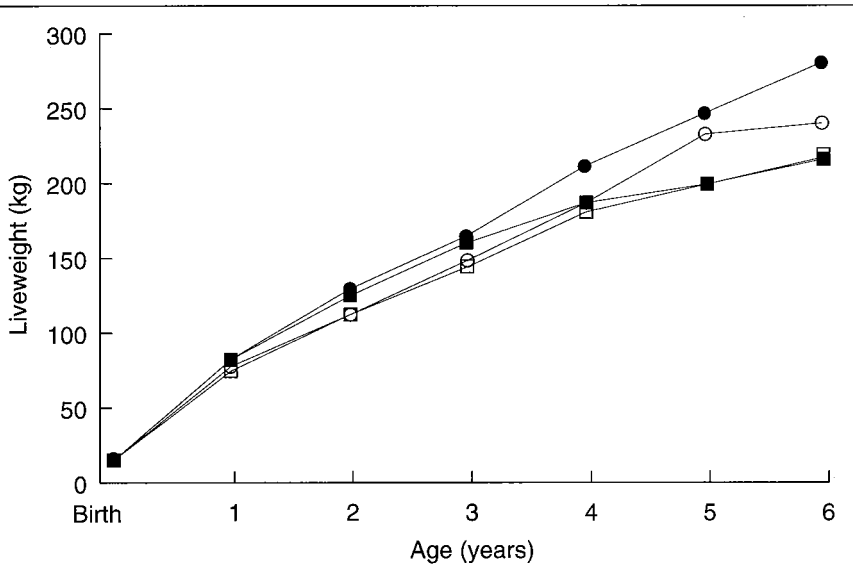


Fig. 4. Average liveweight of N'Dama cattle treated twice with fenbendazole (males, closed circles; females, closed squares) and their controls (males, open circles; females, open squares). (Reproduced, with permission, from Ref. 15.)

animals versus 43.6% in controls ( $P < 0.001$ )<sup>16</sup>. Mortality and milk production were not affected by the treatments; however, surprisingly, a tendentially higher mortality was observed in twice-treated suckling calves. According to a bioeconomic herd model<sup>17</sup> for a financial benefit/cost analysis, the control scheme in cattle was profitable on average, but returns were highly variable and thus can be recommended only in certain herds<sup>18</sup>. In sheep, the same treatment scheme improved both twinning rates (from 1.11 lambs per lambing in controls to 1.19 lambs per lambing in treated animals) and lambing rates (from 1.04 lambs per year in controls to 1.22 lambs per year in treated animals). This

intervention proved to be highly profitable in sheep and can be recommended to farmers in the given economic and climatic context<sup>19</sup>. Furthermore, the overall profitability of sheep-keeping improved considerably through GIN control, whereas the improvement was marginal in cattle<sup>20,21</sup>.

## Extension

Contingency valuation methods were used to estimate the willingness to pay for parasite control<sup>19</sup> and, hence, the probability of its sustainability. GIN control in West African traditional livestock production must be seen in a broader context than animal health alone<sup>18-22</sup>.

Clearly, a parasite control scheme must meet priorities of scarce input allocation in the whole farming system, including labour. Moreover, the parasitologists' timing for deworming may not always coincide with a time when farmers have available cash. Extension problems, although often not considered as 'scientific', are an integral part of research on animal health, aiming ultimately to improve rural living conditions. An increasingly important issue in this context is farmer training.

Ongoing epidemiological work will lead to strategic control studies in various countries of the network. In Côte d'Ivoire and Togo, studies on resistance to anthelmintics have started in ram selection stations. In a joint collaboration of The University of Neuchâtel and Abidjan, botanists and phytochemists are evaluating the potential of the anthelmintic activity of medicinal plants at the Centre Suisse de Recherches Scientifique. Future work is planned on the genetics of resistance to GINs in cattle, but strategic use of anthelmintics will remain a cornerstone of GIN control of livestock in West Africa well into the next century. Hopefully, further partnerships with international centres and the growing number of young national scientists in the region will accelerate developments.

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## Comment

# Can *Trypanosoma* Trees be Trusted?

H. Noyes

Interest in the evolution of the Trypanosomatidae has been rekindled by the publication of three nuclear small subunit ribosomal RNA (SSU rRNA) gene trees<sup>1–3</sup>. These trees have resolved a number of questions but have unexpectedly indicated that the salivarian and stercorarian *Trypanosoma* species of mammals are on quite distinct lineages. The most comprehensive of these phylogenies found that the *Trypanosoma* species appeared in almost the opposite order to that of their hosts and vectors, which was cautiously interpreted to indicate that coevolution was of minor or short-term importance within the *Trypanosoma*. However, the boot-strap values of these trees are frequently low and alternative alignments and phylogeny reconstruction methods yield trees in which all species except the salivarian *Trypanosoma* emerge in the same order as their hosts and vectors (Fig. 1).

The genus *Trypanosoma* comprises at least 472 named species which are parasites of fish (153 spp), amphibians (60 spp), reptiles (79 spp), birds (78 spp) and mammals (102 spp)<sup>4–8</sup>. The mammalian species have been divided into two groups, the salivaria (8 spp), for the species transmitted by the bite of tsetse flies, and the stercoraria (94 spp) for the rest<sup>8</sup>. Although many *Trypanosoma* species names may be synonyms, it is nonetheless striking that the two major branches of the SSU rRNA tree of the genus *Trypanosoma* are represented by eight and 464 nominal species, respectively. The 464 species on one branch are found worldwide in all major vertebrate classes and are transmitted by at

least five orders of vector distributed across two phyla. In contrast, it appears that (until recently) the eight species of salivarian trypanosomes were restricted to a single genus of vector, a single continent and four orders of mammals<sup>8</sup>.

The position of the salivarian *Trypanosoma* species external to all other trypanosomes is well supported by the SSU rRNA trees and is consistent with the growing body of data showing large differences between the genomes of *T. brucei* and *T. cruzi*<sup>9,10</sup>. It has been suggested that the salivarian trypanosomes originated as early as the Pre-Cambrian<sup>1</sup>. The SSU rRNA tree indicates that the salivarian *Trypanosoma* are more diverse than all the other *Trypanosoma* species together (Fig. 1). If the salivarian parasites did arise in the Cambrian or Pre-Cambrian they appeared long before their modern hosts or vectors and made multiple switches into glossinids after that family appeared in the Cretaceous, and into bovids after that family migrated into Africa in the Miocene (25–5 million years ago). The non salivarian trypanosomes could conceivably have coevolved with their hosts and vectors, although the evidence for this is contradictory<sup>3</sup> (Fig. 1).

Alternatively, the topology of the *Trypanosoma* SSU rRNA tree may be an artefact of unequal evolutionary rates. As Maslov et al.<sup>3</sup> point out, a phenomenon known as long-branch attraction causes unusually long branches to be drawn towards the outgroup<sup>11</sup>. Therefore, if the SSU rRNA gene of the salivarian *Trypanosoma* is evolving much faster than the other trypanosomes they

would be drawn towards the bodonid outgroup and hence generate the observed trees. The relative-rate tests that are normally used to detect differences in evolutionary rate fail if rate differences are so extreme as to distort the topology of the tree, and consequently are not applicable to this problem. Support for rate inequalities in the SSU rRNA gene comes from phylogenies of protein coding genes which indicate a much closer relationship between *T. brucei* and *T. cruzi* than do the SSU rRNA trees<sup>12</sup>.

There are at least four possible mechanisms that could have contributed to an increased evolutionary rate in the salivarian *Trypanosoma*.

(1) The generation time of *Trypanosoma* in the field has not been determined; however, if each antigenic variant of the salivarian *Trypanosoma* is considered as a generation, then these parasites may cycle through numerous generations in the vertebrate host between transmission events. In contrast, the stercorarian parasites are characterized by infections with a relatively slow turnover of parasites after an initial expansion and consequently may go through fewer generations between transmission events than the salivarian parasites.

(2) Genetic recombination between *T. brucei* subspecies and strains has been demonstrated in the laboratory and appears to take place in the salivary glands of the vector<sup>13</sup>. Only circumstantial evidence has been found for genetic exchange between *T. cruzi* strains<sup>14</sup> and genetic exchange may therefore either not occur or be much less frequent.