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PORCINE COCCIDIA IN PAPUA NEW GUINEA

THOMAS VARGHESE[1]

Faculty of Agriculture, P.O. Box 306, University of Papua New Guinea (Papua New Guinea)

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ABSTRACT

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Faecal samples from 232 domestic pigs raised on concrete, 98 free-ranging village pigs, and five wild boar showed 46.6 (108/232), 54 (53/98) and 80% (4/5) prevalence of coccidian oocysts, respectively. Eight species of *Eimeria*, and *Isospora suis*, were recovered. In their descending order of predominance in the pigs raised on concrete, the species of coccidia were *E. debliecki* (26.7%), *E. scabra* (22.4%), *E. neodebliecki* (19.8%), *E. porci* (15.5%), *E. suis* (11.6%), *E. polita* (8.6%), *E. perminuta* (7%), *E. spinosa* (5.6%) and *I. suis* (3.9%). The first five species listed above predominated in the village pigs as well. *E. polita, E. spinosa* and *I. suis* were not found in the wild boar. *I. suis* oocysts prevailed in 8.3% of the 36 sows on concrete, and in 11.1% (3/27) of those which were positive for coccidia. Isosporoid oocysts were absent in the village sows. Of the 125 <24-day-old piglets, 29.6% were diarrhoeic, and of these, 43.2% were positive for coccidia. Four of the 16 (25%) coccidia-positive, diarrhoeic piglets, and four of the 37 (10.8%) coccidia-positive non-diarrhoeic piglets shed *I. suis* oocysts, an observation which seems to weaken the present contention that *I. suis* is the primary causative agent of neonatal porcine coccidiosis. The highest mean number of oocysts per gram faeces (23 550) was recorded from the diarrhoeic farm piglets on concrete, and the lowest of 6,100 from the gestating farm sows. Mean opg data revealed very little significant quantitative variation between the corresponding age groups of the free-ranging village pigs and the commercially-farmed ones. One of the most interesting findings in the study was that the sows were more frequently infected than all other age groups.

INTRODUCTION

The pig in Papua New Guinea (PNG) is not only the prime and preferred source of protein to the rural and urban populations, but it also enjoys unique status as a symbol of wealth in the social hierarchy, and is a critical constituent of the 'bride-price' payment. Carbon dating of pig bones excavated from the highland areas of PNG indicate that pig formed a part of

[1] Present address: Nalonnil House, Venmoney, P.O., Kerala State, India.

the diet of the indigenous people as long as 5500 years ago (White, 1968). For the above reasons, and to minimize imports, the post-independence government of PNG has formed policies to boost pig production at the village, semi-commercial and commercial levels. Recent statistics set the population of pigs in the village open-range subsistence system alone at 1.2 million (personal communication, 1984). Nonetheless, there exists to date little information on the parasites of pigs and their impact, if any, on pig production in PNG. This, coupled with the suspected outbreak in 1981 of coccidiosis in two of the major pig farms in the Port Moresby area and the many reports on the occurrence of porcine neonatal coccidiosis in other parts of the world, prompted the present study (Stuart et al., 1978, 1980; Morin et al., 1980; Roberts et al., 1980; Coussement et al., 1981; Eustis and Nelson, 1981; Sanford and Josephson, 1981).

MATERIALS AND METHODS

Of the 330 faecal samples collected from pigs of various age-groups in the Port Moresby area during November 1981—March 1982, 232 samples were from pigs raised on concrete in two commercial farms with similar, modern production practices, and 98 were from free-ranging and scavenging village pigs. In addition, intestinal contents from five wild boars which were killed by villagers were also obtained during the same period. In the Parasitology Research Laboratory of the University of PNG, the faecal samples were macerated in 2.5% (w/v) potassium dichromate solution, filtered through cheesecloth, and placed in thin layers in Petridishes for 14 days at room temperature (24—26° C) to allow sporulation of oocysts. Centrifugal flotation in concentrated NaCl solution was used to concentrate oocysts for microscopic observation, and counting of oocysts per gram (opg) faeces was done according to the modified McMaster method. Identification of oocysts strictly followed previously published descriptions of oocysts of porcine coccidia (Biester and Murray, 1934; Vetterling, 1965; Pellérdy, 1974). Data on the general prevalence of coccidia, predominance of each species observed, and oocysts per gram faeces were collected separately for diarrhoeic and non-diarrhoeic piglets (<24 days), weaners (>24 days—6 months), lactating sows, and gestating sows (Tables I and II, Fig. 1).

RESULTS

One hundred and sixty-one of the 330 samples from domestic pigs (48.8%) were positive for coccidian oocysts. Coccidiasis was found in 79.0 (15/19), 70.6 (12/17), 47.5 (56/118), 36.3 (8/22) and 30.4% (17/56) of lactating sows, gestating sows, weaner pigs, diarrhoeic piglets and non-diarrhoeic piglets on concrete, respectively. Percentage prevalence of oocysts in the five corresponding age groups of free-ranging village pigs were 66.7 (4/6), 50 (2/4), 46.3 (19/41), 53.3 (8/15) and 62.5 (20/32). Of the five samples from

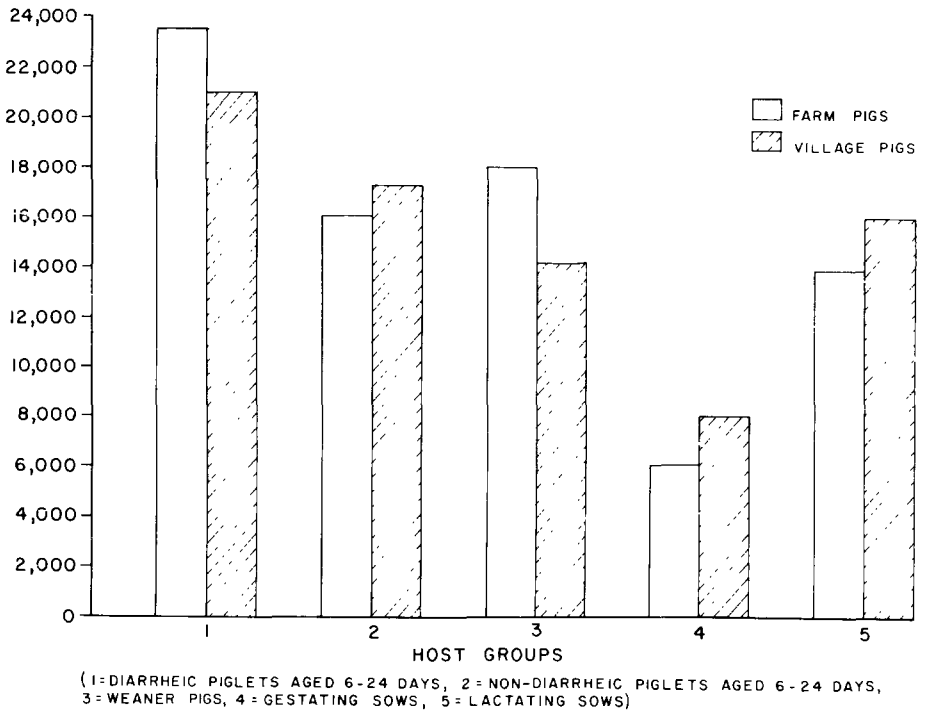

Fig. 1. Mean oocysts per gram faeces of pigs which were positive for coccidia.

the wild boar, four were positive for coccidia. The results showed substantially higher percentage incidences of oocysts in the diarrhoeic (53.3%) and non-diarrhoeic (62.5%) village piglets compared to 36.6 and 30.4%, respectively, of their counterparts in the commercial farms. On the other hand, the farm-raised weaners and sows showed comparatively higher prevalence of oocysts than the free-ranging ones in the village system (Table I). The cumulative prevalence of oocysts in all the age groups of the farm-raised and village pigs was 46.6 (108/232) and 54.0% (53/98), respectively.

Nine of the 15 known species of porcine coccidia were recovered from the samples (Table I). In their decreasing order of predominance in all the age groups of the pigs raised on concrete, the species observed were *Eimeria debliecki* (26.7%), *E. scabra* (22.4%), *E. neodebliecki* (19.8%), *E. porci* (15.5%), *E. suis* (11.6%), *E. polita* (8.6%), *E. perminuta* (6.9%), *E. spinosa* (5.6%) and *Isospora suis* (3.9%). In the village pigs also, the first five species listed above predominated, with slight variations in the percentage of their prevalence. Oocysts of *E. polita*, *E. spinosa* and *I. suis* were each found in 4%, and *E. perminuta* in 8.2%, of the village pigs. The total prevalence of *I. suis* in the 330 pigs sampled was 3.9%, and this coccidium was not recovered from the lactating and gestating village sows and the 5 wild boar (Table I).

TABLE I

Prevalence of coccidian oocysts in swine in Papua New Guinea

Host group	Number examined	Number positive[1]	Species of coccidia[2]		
			E. scabra	*E. debliecki*	*E. porci*
Sus scrofa domestica					
Gestating sows	17, 4[3]	12 , 2 (70.6, 50)[4]	8 , 2 (47.1, 50.0)	7 , 2 (41.2, 50.0)	7 , 1 (41.2, 25.0)
Lactating sows	19, 6	15 , 4 (79.0, 66.7)	10 , 1 (52.6, 16.7)	11 , 2 (57.9, 33.3)	9 , 3 (47.4, 50.0)
Weaner pigs	118, 41	56 , 19 (47.5, 46.3)	24 , 6 (20.3, 14.6)	27 , 9 (22.9, 21.9)	13 , 5 (11.0, 12.2)
Nursing piglets with diarrhoea[5]	22, 15	8 , 8 (36.4, 53.3)	2 , 5 (9.1, 33.3)	4 , 6 (18.2, 40.0)	1 , 2 (4.5, 13.3)
Nursing piglets without diarrhoea[5]	56, 32	17 , 20 (30.4, 62.5)	8 , 9 (14.3, 28.1)	13 , 5 (23.2, 15.6)	6 , 8 (10.7, 25.0)
Total	232, 98	108 , 53 (46.6, 54.1)	52 , 23 (22.4, 23.5)	62 , 24 (26.7, 24.5)	36 , 19 (15.5, 19.4)
Sus scrofa scrofa					
Wild boar	5	4 (80)	1 (20)	2 (40)	1 (20)

[1] Due to mixed infections, the sum of individual infections is greater than the number of animals which were positive for coccidia.
[2] *E = Eimeria, I = Isospora.*
[3] The second set of figures in all the columns refers to free-ranging village pigs, and the first to commercially-farmed pigs.
[4] Numbers within parentheses refer to percentage prevalence of coccidian oocysts.
[5] Piglets aged 6—24 days.

Of the 125 piglets examined, 29.6% were diarrhoeic, and of these, 43.2% were positive for coccidian oocysts. *I. suis* oocysts were found in 25% of the 16 diarrhoeic piglets which had coccidia, and 10.8% of the 37/88 non-diarrhoeic piglets which were positive for coccidia.

Figure 1 summarizes the mean opg data for the five groups of both farm and village-raised pigs which were positive for coccidia. The highest mean opg (23 550) was recorded from the diarrhoeic farm piglets on concrete, and the lowest (6100) from the gestating farm sows. Because of the insufficiency of the samples from the wild boar, opg counts were not taken.

E. neo-deblieckí	*E. suis*	*E. polita*	*E. perminuta*	*E. spinosa*	*I. suis*
5 , 1 (29.4, 25.0)	6 , 0 (35.3, 0)	4 , 1 (23.5, 25.0)	2 , 0 (11.8, 0)	1 , 0 (5.9, 0)	1 , 0 (5.9, 0)
7 , 2 (36.8, 33.3)	9 , 2 (47.4, 33.3)	1 , 0 (5.3, 0)	1 , 1 (5.3, 16.7)	0 , 0 (0 , 0)	2 , 0 (10.5, 0)
23 , 6 (19.5, 14.6)	12 , 7 (10.2, 17.1)	13 , 2 (11.0, 4.9)	11 , 2 (9.3, 4.9)	6 , 1 (5.1, 2.9)	1 , 1 (0.85, 2.4)
2 , 3 (9.0, 2.0)	0 , 2 (0 ,13.3)	0 , 1 (0 , 6.7)	1 , 2 (4.5, 13.3)	0 , 1 (0 , 6.7)	2 , 2 (9.0, 13.3)
9 , 9 (16.1, 28.1)	0 , 3 (0 , 9.4)	2 , 0 (3.6, 0)	1 , 3 (1.8, 9.4)	1 , 2 (1.8, 6.3)	3 , 1 (5.4, 3.1)
46 , 21 (19.8, 21.4)	27 , 14 (11.6, 14.3)	20 , 4 (8.6, 4.1)	16 , 8 (6.9, 8.2)	8 , 4 (3.4, 4.1)	9 , 4 (3.9, 4.1)
1 (20)	1 (20)	0	1 (20)	0	0

DISCUSSION

Eimeria debliecki, *E. scabra* and *Isospora suis* have been the only three species of swine coccidia so far reported from PNG (AMVSU Report, 1946). The observation in the present study of an additonal six species of *Eimera* (*E. porci*, *E. neodebliecki*, *E. suis*, *E. polita*, *E. perminuta* and *E. spinosa*) brings the total number of coccidian species found in domesticated PNG pigs to nine, a finding in accordance with those from the rest of the world (Vetterling, 1965, 1966; Pellérdy, 1974; Greiner et al., 1982; Lindsay et al.,

TABLE II

Prevalence (%) of the common species of coccidia of domestic and feral swine: a comparison of results from the present study and three earlier reports

Species of coccidia	*Sus scrofa domestica*												*Sus scrofa scrofa*	
	Vetterling (1966)				Lindsay et al. (1984)		Present study						Greiner et al. (1982)	Present study
	≥3 weeks–6 months		≥6 months		Sows		<24 days[1]		≥24 days–6 months		Sows[2]		Wild boar	Wild boar
	(C)[3]	(P)	(C)	(P)	(W)	(WO)	(C)	(D)	(C)	(V)	(C)	(V)		
Eimeria deblieckl	1.6	36.9	0	0	59.7	62.2	21.8	14.1	22.9	22.0	50.0	40.0	41.0	40.0
E. neodebliecki	1.6	55.9	5.7	53.3	59.7	45.9	14.1	25.5	19.5	14.6	33.3	30.0	33.0	20.0
E. perminuta	0	0.8	0	0	7.8	6.4	2.6	10.6	9.3	4.9	8.3	10.0	9.0	20.0
E. polita	0	0	0	0	15.6	27.9	2.6	2.1	11.0	12.2	13.9	10.0	10.0	0
E. porci	0	28.0	0	40.0	45.5	59.3	9.0	21.3	11.0	14.6	44.4	40.0	45.0	40.0
E. scabra	1.6	53.8	2.9	40.0	26.0	63.4	12.8	29.8	20.3	17.0	50.0	30.0	27.0	20.0
E. suis	0	16.1	2.9	47.7	50.6	26.2	0	10.6	10.1	0.84	41.7	20.0	24.0	20.0
E. spinosa	0	25.4	0	26.6	0	2.9	1.3	2.1	5.0	0	2.8	0	1.0	0
E. cerdonis	0	12.7	0	13.3	0	0	0	0	0	0	0	0	12.0	0
Isospora suis	0	0.8	0	0	0	0.6	6.4	6.4	0.84	0.84	8.3	0	2.0	0
Total	1.6	59.8	5.7	60.0	81.8	94.8	32.0	59.6	47.5	46.3	75.0	60.0	87.0	80.0

[1] Includes both diarrhoeic and non-diarrhoeic piglets.

[2] Includes gestating and lactating sows.

[3] (C) = Concrete, (P) = pasture, (D) = nursing piglets confined to dirt-lot pens, (V) = free-ranging village pigs, (W) sows from farms with a history of neonatal coccidiosis due to *Isospora suis* infections, (WO) = sows from farms with no history of neonatal coccidiosis due to *I. suis*.

1984). The failure to find oocysts of *E. residualis*, *E. betica*, *E. scrofae*, *E. romaniae*, *E. guevarai*, *I. almaatensis* and *I. neyrai* in 249 sows and 251 free-ranging feral swine in the United States, and in the present study, indicates either that these species are limited to Europe, or that their species status is doubtful (Rodriguez and Herrera, 1971; Gomez et al., 1974; Pellérdy, 1974.

Coccidian oocysts were reported in 60% of swine raised on pastures and 2.4% of swine on concrete (Vetterling, 1966). In a recent survey, Lindsay et al. (1984) reported the presence of coccidia in 81.8% of sows from farms with a history of *I. suis* coccidiosis, and in 94.8% of sows from farms without such a history. Coccidian oocysts were also found in 87 and 87.5% of feral swine in two surveys (Wheat and Cook, 1979; Greiner et al., 1982). The present finding that 48.8% of the pigs sampled had coccidia (108/232 of the farm pigs raised on concrete and 53/98 of the free-ranging village pigs) confirms for the first time that coccidia are common parasites of pigs in PNG.

A comparison of the total percentage prevalence of coccidia reported in domestic pigs by Vetterling (1965) and Lindsay et al. (1984), and in feral swine by Greiner et al. (1982) with the results obtained in the present study (Table II) shows that the 46.6 and 54% prevalence in the commercially-farmed pigs on concrete and village pigs, respectively (Table I), is considerably lower. While the effective sanitary controls and hygiene practices prevailing at the commercial farms account for the lower prevalence of coccidia in pigs from these farms, one would have expected a much higher prevalence of coccidia in the scavenging village pigs. Perhaps the absence of confinement, and the free-ranging and ad libitum foraging habits of these pigs in an area of about 3—4 km of open bush boosted their resistance to coccidiasis and/or minimized the rate of re-infection. No other viable explanation to this rather intriguing finding can be offered until further detailed comparative studies are completed.

Vetterling (1966) found all his 33 <3-week-old piglets to be free of coccidia, and 1.6 and 59.8% of weaners raised on concrete and pasture, respectively, to be positive for coccidia. My finding that 32 and 59.6% of the 6—24-day-old piglets raised on concrete and dirt pens, respectively, and 47.5% of the weaners on concrete had one or more species of coccidia (Table II) differs substantially from that of the above author. Eustis and Nelson (1981) reported that 62.2% of the diarrhoeic piglets they sampled had coccidiosis, and Sanford found neonatal porcine coccidiosis in 20.5% (258/1453) of piglets, and *I. suis* coccidiosis in 7% of those positive for coccidia. The present finding of *I. suis* oocysts in 6.4% of piglets (Tables I and II) is comparable to the findings of the above author. The total prevalence of *I. suis* oocysts in 3.9% of the 330 pigs sampled in the study is comparatively higher than that reported in domestic and feral swine by previous workers (Vetterling, 1966; Greiner et al., 1982).

Lindsay et al. (1984) reported the absence of *I. suis* in 77 sows from farms with a history of *I. suis* coccidiosis and only 0.6% prevalence of *I. suis* in 172 sows from farms without a history of isosporoid coccidiosis (Table II), a

finding very similar to that of Vetterling (1966). However, the finding in the present study that 8.3% of the sows on concrete were positive for *I. suis* (Tables I and II) does not support the contention of Lindsay et al. (1984) that "*I. suis* is not widely prevalent in adult swine". In fact, the 8.3% prevalence of *I. suis* in the sows on concrete equalled that of *E. perminuta* and exceeded that of *E. spinosa* (2.8%). This, coupled with the cumulative prevalence of *I. suis* in 6.4 and 1.3% of piglets and weaners, respectively (Table II), indicates that *I. suis* is not an uncommon porcine coccidium in PNG. However, the finding that none of the 6 lactating and 4 gestating village sows were positive for *I. suis* when 2/19 and 1/17 farm sows were (Table I), is intriguing, particularly since the samples were collected directly from the rectum and the identification of *I. suis* oocysts strictly followed its species-specific characteristics (Biester and Murray, 1934; Vetterling, 1965), and also in view of the fact that the less hygienic village conditions ought to be more conducive to the spread of coccidia. The only logical explanation for this finding perhaps rests in the fact that the number of village sows (10 only) sampled was too small a group to reveal all the species of coccidia; a conclusion which may also explain why four of the 10 species of coccidia reported from feral swine in the United States were not detected in the five wild boar (Tables I and II) in the present study (Wheat and Cook, 1973; Greiner et al., 1982).

Transmissible gastroenteritis virus (Pensaert et al., 1970), corona-like virus (Debouck and Pensaert, 1980), rotavirus (Pearson and McNulty, 1977), haemolytic *Escherichia coli* (Kramer and Nderito, 1967), *Strongyloides ransomi* (Sangster et al., 1978), species of *Eimeria* and *Isospora suis* (Roberts et al., 1980; Stuart et al., 1980; Coussement et al., 1981; Eustis and Nelson, 1981; Robinson and Morin, 1982; Robinson et al., 1983; have been associated with the occurrence of scouring and diarrhoea in neonatal pigs. Although microbiological and histopathological data were not attempted from the diarrhoeic piglets in the present study, the finding that of the total of 37 diarrhoeic piglets only 16 (43.2%) were positive for coccidia, and of the 16 positive only 4 (25%) shed oocysts of *I. suis* (Table I) seems to dwarf the diarrhoeic attributes of *Eimeria* spp. and *Isospora suis* in neonatal pigs. Furthermore, the observation that of the 88 non-diarrhoeic piglets sampled, although 37 were positive for coccidia and of these 4 harboured *I. suis*, none had any symptoms of diarrhoea prompts the question: do these genera of parasites cause coccidiasis or coccidiosis? An appraisal of the literature cited above and the present results suggest that porcine neonatal diarrhoea and associated symptoms are perhaps the cumulative manifestation of more than one group of intestinal parasites.

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