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The behaviour of free ranging pigs in the Mexican tropics and its relationships with human faeces consumption

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Abstract

There is no information on how free ranging pigs in the Mexican tropics distribute their time during the day and how these time budgets relate to their age and social behaviour of the pigs. It is known that in these areas pigs consume human faeces, which constitutes a serious public health problem as it maintains the life cycle of *Taenia solium*. The study was carried out in a community of the state of Guerrero, Mexico, where five groups of free ranging pigs were observed during the dry and rainy seasons. A combination of scan and behaviour sampling was carried out to obtain information on time budgets and social interactions of adult, sub-adult, and juvenile pigs. On average the pigs spent significantly more time feeding and in locomotion during the rainy season (12.0 and 25.2%, respectively) than during the dry season (5.9 and 13.6%, respectively). Also, they spent more time resting and exploring during the dry season (69.2 and 11.2%, respectively) than during the rainy season (56.9 and 5.0%, respectively). The frequency of human faeces consumption was higher during the dry season. In both seasons the leaders of the groups, which were usually adult females, ate human faeces significantly more frequently than other pigs. On average, the pigs walked less than half the distance during the dry season than during the rainy season. In general, the frequency of non-agonistic interactions was higher than agonistic interactions in adult, sub-adult, and juvenile pigs. Adult sows were socially the most active group as they performed agonistic and non-agonistic interactions more frequently than other individuals. The interactions within age groups were more frequent than between groups. This information is useful to improve management practices of these pigs in the Mexican tropics as well as to better understand individual susceptibility to infection by *T. solium* as well as to how they acquire immunity to that parasite.
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1. Introduction

Pigs under free ranging conditions are generally exploratory animals that spend most of the active time of day in locomotion (Stolba and Wood-Gush, 1989). Pigs can invest 50% of time in foraging, starting at dawn and finishing at dusk (Curtis, 1989). Usually, the daily activity pattern of adult individuals is diurnal; but when temperatures are high pigs can be crepuscular or nocturnal (Signoret et al., 1975; Pond and Houpt, 1981; Graves, 1984). Graves (1984) mentions that on cloudy and rainy days pigs can be active all day, but on warm days they are active early in the morning and late at night.

As a sociable species, pigs forage in family groups (Jensen and Wood-Gush, 1984; Newberry and Wood-Gush, 1988). In a family group, the dominant individuals defend a territory within their home range, were food is available. In European and North American countries, during the fall and winter this home range can be smaller than in the summer. In this geographical region the diet of rural pigs can range from small plants, tubers, roots, seeds, grass, and leaves, to earthworms, caterpillars, snakes, nuts, grapes, frogs, eggs, and even small rodents (Signoret et al., 1975; Graves, 1984). Overall, the amount of food obtained is a very important factor, probably even more so than territorial behaviours (Stolba and Wood-Gush, 1981). In this sense, Newberry and Wood-Gush (1988) mention that rooting and smelling the soil occupies a greater proportion of time than do social behaviours.

It is not known how pigs in extensive conditions of the dry tropics of Mexico distribute their time and how their individual time budgets relate to their age and social behaviour. It has been observed that in many rural communities of tropical countries where pigs forage extensively, they frequently eat human faeces from latrines or from the fields (de Aluja, 1982; Nemeth, 1990). Nemeth (1990) reports that on the Island of Cheju, Korea, there is physical access between the latrines and pigpens so that the animals can forage on the faeces. Pigs can be considered to function as natural sources of sanitation, as they clean the villages of faecal material and garbage. de Aluja (1982) indicates that the presence of faecal material is a serious public health problem, specifically in relation to the Taeniasis–Cysticercosis cycle, due to the permanent parasitosis of the pig and the consumption of their infected meat by the people. However, it is still not known how the social behaviour of pigs in the rural areas of the Mexican tropics relates to foraging behaviour, and particularly to the consumption of human faeces, and if this varies during the year. It would be useful to know more about the behaviour of the rural Mexican pigs, and which individuals are more likely to consume human faeces. This would enable a better understanding as to how pigs inside a group are more likely to become infected or acquire immunity to *Taenia solium*.

2. Methods

2.1. Location and subjects

This study was carried out in the village of Tianquizolco, in the Mexican State of Guerrero. The village is located in a mountainous area at 1100 m altitude. It has a hot, sub-humid climate with rains in the summer and has an average temperature of 26.9 °C (García, 1981). This community has a population of 900 people living in 182 houses. Of these, only one

Table 1
Physical structure of the groups of pigs observed in during the dry (d) and rainy (r) seasons

	Group											
	AF (d)	AM (d)	SF (d)	SM (d)	JF (d)	JM (d)	AF (r)	AM (r)	SF (r)	SM (r)	JF (r)	JM (r)
1	2	1	1	5	0	0	2	4	3	2	3	3
2	3	3	0	1	2	2	2	3	3	0	2	3
3	4	0	0	2	9	0	0	3	5	3	3	2
4	2	0	5	4	2	3	0	3	2	2	0	0
5	1	8	2	1	1	4	2	1	1	3	0	0
Total	12	12	8	13	14	9	6	14	14	10	8	8

AF, adult females; AM, adult males; SF, sub-adult females; SM, sub-adult males; JF, juvenile females; JM, juvenile males.

has tap water, four have drainage, and only three use latrines. This is a community that has been studied before for an epidemiological survey on *Taeniasis* (de Aluja et al., 1998) and was chosen because the pigs roam freely during the day, and the frequency of outdoors defecation by people is high. At 0600 h, the pigs are given a very small amount of maize, more as a conditioning stimulus for them to return to their house at night, rather than for nutritional purposes. The pigs return to the village and houses at dusk.

Five groups of free ranging pigs were followed and observed during the dry (February–April) and rainy (August–October) seasons. These groups forage as separate social units as each of them belong to a different family of the community and, as said before, they are fed on maize to make them return to the family house. The pigs were identified by their natural marks in combination with spray painting according to their size and sex (AF, adult females; AM, adult males; SF, sub-adult females; SM, sub-adult males; J, juvenile). Juveniles corresponded to nursing individuals (up to 3 months of age), sub-adult pigs were those weaned but not sexually mature (3–12 months), and the adults were those pigs sexually mature (12 months or more). The composition of the five groups observed in each season can be seen in Table 1.

2.2. Behavioural measurements

A total of 50 days of observations were used in each season. The groups were observed by alternating a group every day. On each observation day the group of pigs was followed from a distance and observed from 0600 to 1800 h. Overall, each group was observed for 10 days during each season. The environmental temperature was recorded every 30 min during the 12 h of observation in each day. The average of the 24 records was calculated as the day's average temperature. A combination of scan and behaviour sampling was used (Martin and Bateson, 1986). A scan was carried out every 30 min during the 12 h of observations in order to record individual behaviour of all pigs in the observed group. For each animal the time spent in maintenance behaviours during the study was expressed as proportion of observations. Behavioural sampling was used between scans and all events of performing and receiving agonistic and non-agonistic interactions were recorded. From this information individual time budgets and frequencies of social interactions were calculated.

The individual behaviours considered were: foraging, which included drinking, and ingesting faeces; resting, which included lying behaviour with eyes closed or open; exploration, which included rooting and smelling; and locomotion, which included walking, standing, and trotting. Agonistic interactions included, frontal attacks, bites, chases, and fights, while non-agonistic interactions included nasal contact, rubbing, marking (placing the snout on the body of another individual), and mounting. Social behaviour was only recorded during the dry season as all pigs were too dispersed during the rainy season resulting in little competition or social contact.

In addition, an estimate of the daily distance walked by the group of pigs observed was calculated using a manual counter to count the frequency of steps taken by the observer as he followed those individuals that stayed closer to each other.

2.3. Statistical analysis

A multivariate analysis of variance (MANOVA) for repeated measures, after a squared root data transformation (Tukey, 1977) was used to analyse the effect of time of day, sex, age, and season on the proportion of time each of the five groups, according to age/gender (AF, adult females; AM, adult males; SF, sub-adult females; SM, sub-adult males; J, juvenile), dedicated to maintenance behaviours. To compare the proportion of time in maintenance behaviours between seasons and the frequency of social interactions between age/gender groups, a *z* proportion test was used. Student's *t*-test was also used to compare the average daily distance walked, and the average daily temperature between seasons.

3. Results

3.1. Maintenance behaviour

The season and time of day had an effect on the time spent foraging, exploring, resting, and in locomotion ($F = 2.45$, d.f. $= 21$, $P < 0.05$; $F = 2.37$, d.f. $= 21$, $P < 0.05$; $F = 2.32$, d.f. $= 21$, $P < 0.05$; $F = 2.37$, d.f. $= 21$, $P < 0.05$), however, age and sex did not influence any of the behaviours recorded ($F = 0.99$, d.f. $= 21$, $P > 0.05$; $F = 0.52$, d.f. $= 21$, $P > 0.05$). On average, the pigs spent more time feeding and in locomotion during the rainy season ($z = 5.11$, $P < 0.05$; $z = -3.2$, $P < 0.01$), and spent more time resting and exploring during the dry season ($z = 5.58$, $P < 0.05$; $z = -5.18$, $P < 0.05$, Table 2).

The way those behaviours were distributed during the day also differed between seasons. The time spent foraging and in locomotion during the dry season was concentrated from 0600 to 0900 h and from 1600 to 1800 h, but during the rainy season these behaviours were carried out mostly between 1000 and 1500 h ($z = 2.5$, $P < 0.01$; Fig. 1). In contrast, when looking at the distribution of time resting in both seasons, it was seen that these behaviours were concentrated from 0900 to 1500 h during the dry season, and during the rainy season pigs rested more between 0700 and 0800 and between 1500 and 1800 h ($z = 6.4$, $P < 0.01$; Fig. 1). Although, the time exploring was higher during the dry season, it coincided when the pigs were in locomotion and feeding, and was mostly concentrated from 0600 to 0900 h

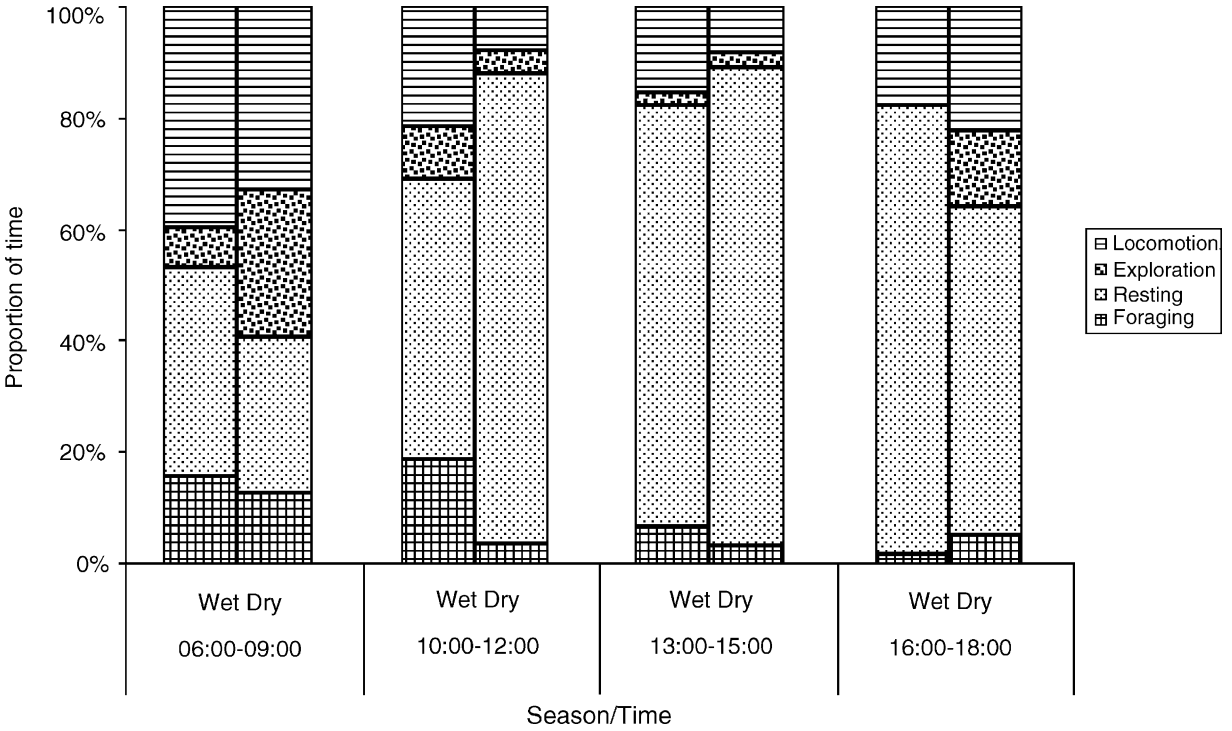

Fig. 1. Proportion of time in maintenance behaviours across the day for both seasons.

Table 2
Mean proportion of time in maintenance behaviours (±S.E.M.) for pigs of different age groups during the rainy season

Group	Foraging	Resting	Exploration	Locomotion
Rainy season				
Adult	12.0 ± 0.08	56.9 ± 0.19	5.0 ± 0.04	25.2 ± 0.10
Sub-adult	9.7 ± 0.07	61.8 ± 0.20	8.5 ± 0.07	21.0 ± 0.10
Juvenile	11.9 ± 0.10	64.4 ± 0.24	0.8 ± 0.01	27.3 ± 0.13
	11.2 ± 0.08	61.0 ± 0.21	4.8 ± 0.04	24.5 ± 0.11
Dry season				
Adult	5.9 ± 0.10	69.2 ± 0.29	11.2 ± 0.11	13.6 ± 0.12
Sub-adult	2.9 ± 0.04	57.8 ± 0.27	15.5 ± 0.14	23.9 ± 0.12
Juvenile	9.6 ± 0.09	60.8 ± 0.29	11.9 ± 0.13	17.8 ± 0.15
	6.1 ± 0.08	62.6 ± 0.28	12.9 ± 0.13	18.4 ± 0.13

and from 1600 to 1800 h, while this behaviour was more frequent during the rainy season from 0900 to 1500 h ($z = -5.18$, $P < 0.01$; Fig. 1).

On average, the pigs walked 1023 ± 493 m per day during the dry season, while the average daily distance during the rainy season was of 2775 ± 1429 m ($P < 0.05$). The average daily temperature for the dry and rainy seasons, respectively, were 27.0 °C (±4.6) and 23.5 °C (±2.7) ($t = -2.5$, $P < 0.05$).

3.2. Social behaviour

A total of 442 interactions were recorded during the dry season. Of these, 382 (86.4%) were intra-group social interactions performed between the pigs in a group, and 60 (13.6%) corresponded to social interactions between pigs from different groups including unknown pigs from groups not observed. Of the 382 intra-group interactions recorded, 63.2% corresponded to non-agonistic interactions and 36.8% were agonistic interactions. The AF was the group with the highest frequency of agonistic interactions while the SF had the lowest frequency of that behaviour ($z = 6.97$, $P < 0.01$; Table 3). Also, AF performed significantly more non-agonistic interactions while the group of SM were less likely to start a non-agonistic interaction ($z = 3.35$, $P < 0.05$; Table 3).

Table 3
Distribution of the number and percentage of agonistic and non-agonistic interactions performed by pigs observed according to different age/sex groups

Age group	Agonistic interactions		Non-agonistic interactions		Total interactions	
	Number	Percentage	Number	Percentage	Number	Percentage
AF	67	17.5	145	38.0	212	55.5
AM	34	8.9	53	13.9	87	22.8
SF	14	3.7	28	7.3	42	11.0
SM	26	6.8	15	3.9	41	10.7
Total	141	36.9	241	63.1	382	100

AF, adult females; AM, adult males; SF, sub-adult females; SM, sub-adult males.

Table 4
Matrix of agonistic and non-agonistic interactions performed by pigs of different age groups

Animals performing behaviour	Recipients of behaviour									
	AF		AM		SF		SM		Total	
	Agonistic	Non-agonistic	Agonistic	Non-agonistic	Agonistic	Non-agonistic	Agonistic	Non-agonistic	Agonistic	Non-agonistic
AF										
Number	17	78	12	16	15	13	23	38	67	145
Percentage	25.4	53.8	17.9	11.0	22.4	9.0	34.3	26.2	100	100
AM										
Number	9	17	14	19	3	12	8	5	34	53
Percentage	26.5	32.1	41.2	35.9	8.8	22.6	23.5	9.4	100	100
SF										
Number	1	5	4	3	3	6	6	14	14	28
Percentage	7.1	17.9	28.6	10.7	21.4	21.4	42.9	50	100	100
SM										
Number	0	3	1	1	5	3	20	8	26	16
Percentage	0	18.8	3.9	6.2	19.2	25.0	76.9	50.0	100	100

AF, adult females; AM, adult males; SF, sub-adult females; SM, sub-adult males.

Of all agonistic interactions performed by AF, 34.3% were directed to SM and 25.4% to other AF. The rest of the agonistic interactions performed by this group was directed to AM and SF ($z = 6.97$, $P < 0.05$; Table 4). Of those agonistic interactions performed by AM, 41.2% were directed to other AM, 26.5% to AF, and 23.5% to SM ($z = 2.77$, $P < 0.05$; Table 4). When SM performed agonistic interactions, 76.9% were directed to other SM, and ht rest where directed to AM and SF ($z = 2.77$, $P < 0.05$; Table 4). Finally, when SF performed agonistic interactions, 42.9% were directed to SM and 28.6% to AM ($z = 2.77$, $P < 0.01$; Table 4).

Of the total non-agonistic interactions that AF performed, 53.8% were directed to other AF ($z = 3.55$, $P < 0.01$; Table 4), and of those performed by AM, 35.9% were directed to other AM and 32.1% to AF ($z = 3.55$, $P < 0.01$; Table 4). Also, of those non-agonistic interactions performed by SM, 50% were directed to other SM, while 25.0% to SF ($z = 3.55$, $P < 0.01$; Table 4). Finally, SF performed these behaviours to SM in 53.3% of times ($z = 3.55$, $P < 0.01$; Table 4).

3.3. Consumption of human faeces

The frequency of times the pigs were seen eating human faeces was different between seasons. During the dry season the frequency of faeces consumption was on average 0.95 events/h, while the same frequency during the rainy season was of 0.48 events/h ($P < 0.05$). Moreover, the frequency of these events was not the same in all age groups. In both seasons adult females consumed human faeces more frequently (0.32/h during the dry season, and 0.19/h during the rainy season) than pigs in the other groups ($P < 0.05$). Adult males performed that behaviour more frequently (0.25/h during the dry season, and 0.12/h during the rainy season) than sub-adult and juvenile pigs ($P < 0.05$). There were no differences in the frequency of that behaviour between sub-adult males and sub-adult females during both seasons (0.19/h and 0.08/h; 0.17/h and 0.08/h, for SM and SF during the dry and rainy season, respectively).

4. Discussion

This study was carried out in order to learn more about the behaviour of rural pigs in the Mexican tropics. The season and time of day influenced the time the pigs spent in different maintenance behaviours.

The fact that foraging and locomotion was greater during the rainy season can be explained by the availability and access to different food resources. The results presented here differ from other studies (Mauget, 1981; Stolba and Wood-Gush, 1989), which could be related to the geographical conditions and the type of vegetation where the pigs foraged. Also, due to the variations in the temperature from the dry and rainy seasons, the way they distribute their maintenance behaviours during the day was different. Clearly, the pigs avoided walking in the hours of high temperature, and as a result foraging activities during the dry season were concentrated early in the morning and late afternoon, while these behaviours during the rainy season were more frequent at midday. This was also seen by Graves (1984) and van Vuren (1984) and confirms that when food is scarce and temperature is high the pigs will

increase the time resting. The overall time resting or inactive for the pigs in this study agree with previous studies (Mauget, 1981; Robert et al., 1987) although in those studies it is not specified if the observations were carried out during a rainy or dry weather.

In relation to the social interactions measured, it was seen that the physical structure of the groups included adult sows and males. However, the adult sows were the individuals that interacted more frequently both within and outside the group. This suggests that this is the most active age group socially and that they play an important role in regulating the social order of the groups. This does not necessarily agree with some previous studies where the adult males are the most active individuals (Mauget, 1981). However, it is a common practice in these villages to leave the sow in the group for a longer period than the adult males, and also in most cases the males are castrated. These conditions could have modified the physical and social structure of these groups, and thereby cause the sows to be dominant over many adult males.

As in previous studies (Mauget, 1981, wild pigs; Stolba and Wood-Gush, 1981, free ranging pigs with fence; Graves, 1984, wild pigs; Newberry and Wood-Gush, 1986; Dellmeier and Friend, 1991, domestic pigs), the observed pigs showed a stable hierarchy and strong group cohesion. The fact that interaction performed within age groups was more frequent than interacting with pigs from other age groups also coincides with previous data (Jensen, 1982; Hunter et al., 1988). The frequency of non-agonistic interactions was much higher than the agonistic interactions among all groups, and many of these behaviours were performed while the pigs were inactive or lying one next to the other. This is understandable as these are small family-like groups, with of strong group cohesion and a stable social hierarchy.

Faeces consumption was part of the foraging behaviour and, as presented here, varied between age groups. It is possible that the frequency of faeces consumption was lower during the rainy season because the rains wash away the faeces and this resource is more available for the pig during the dry season. Another explanation could be that as food is scarce during the dry season, human faeces represent a resource to be used to obtain some nutrients. Independently of the seasonal differences, the pigs moved with a definite hierarchical order and the dominant pigs are the first to ingest human faecal material. Other members may then pick up what is left, with none for the juveniles. This information is very useful in understanding susceptibility to infection by *Taenia* spp. de Aluja et al. (1998) found that piglets become infected with *T. solium* at the age of 2–4 weeks during the dry season, but not during the wet season. Although in this study there were no records of piglets eating faeces, it could be hypothesised that they could ingest the eggs by rooting in the same place soon after the adult animal ate the excrement. It is also possible that the piglets were infected by mouth-to-mouth contact, or simply that they ingested eggs at a time they were not observed. This is particularly important as during the dry season the adult animals are more reluctant to move about and the thermoregulatory system of juveniles tolerates heat better, allowing them to access food, which the grown-ups would normally ingest.

As this is the first study on the behaviour of free ranging pigs in the Mexican tropics it contributes in many ways to better understand how management procedures of these animals could be improved. Also the information presented here on the relationships between foraging behaviour and social behaviour of this type of pigs is useful to understand more about how pigs can get infected with *Taenia* eggs.

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