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ECOLOGY AND MANAGEMENT OF FERAL PIGS IN AUSTRALIAN TROPICAL RAINFORESTS

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ABSTRACT: Information on the ecological impacts of feral pigs (*Sus scrofa*) in the World Heritage Listed tropical rainforests of northern Queensland, Australia, are limited. This study quantifies and qualifies aspects of the ecological impact, spatial and temporal digging activities and home range and seasonal movement patterns of feral pigs. Feral pigs have seasonal digging activities with a preference for moist microhabitats at the start of the dry season. Feral pigs in this region have defined sedentary home ranges, and their distribution patterns appear to be influenced by microhabitat factors including earthworm populations and water availability. Digging activity decreases rainforest seedling survival rates by 36%. Management strategies should concentrate on a coordinated, regional, community based approach.

KEY WORDS: feral pig, feral swine, impact, ecological impact, rainforest, vertebrate pest

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INTRODUCTION

The World Heritage Area (WHA) listed rainforests of the wet tropics region of northeast Queensland, Australia covers over 9,000 km² and is regarded as natural heritage of outstanding universal value and one of the most significant regional ecosystems in the world. Feral pigs have been accused of posing many diverse (real or perceived) threats to the conservation values of the World Heritage Area. To understand the "threat" to World Heritage values, information is required on the "actual" impact of feral pigs on this environment. Clarification of the impact of feral pigs in terms of season, severity, diversity and situation is a fundamental component of developing a management plan.

This paper outlines the research currently being undertaken to acquire quantitative knowledge on the ecological impact and ecology aspects of feral pigs within the rainforests of northern Queensland. The research is presented as four studies: spatial and temporal digging patterns, ecological impact of pig diggings, home range and seasonal movement patterns and biological parameters.

METHODS

The study site is situated near Cardwell, north Queensland, Australia (18° 16' S, 146° 2' E). The study site was selected as significant feral pig populations existed in the area (Mitchell and Mayer 1997) and a variety of habitat types were available within the region, ranging from highland rainforests to lowland dry rainforest, open woodlands, marine swamps and mangroves. The variety of habitat types was ideal for assessing the influence of microhabitat and macrohabitat factors on feral pig spatial patterns.

The study region was divided into three broad macrohabitats defined by broad biogeographical "areas," these include highland rainforests, the ecotone between rainforests and cropping systems and the coastal lowlands. Within each of the three areas, a number of key microhabitat termed "strata" were selected based on the presence of pig activity, previously established microhabitat preferences (Mitchell and Mayer 1997) and

representing the major microhabitat types available in the area.

1. Spatial and Temporal Digging Patterns

Patterns of feral pig digging (rooting) activity, both spatially (between macro and microhabitats) and temporally (between seasons) were monitored over a two year period. Associations between these digging patterns and soil moisture and earthworm population levels were also examined.

Three macrohabitat areas were assessed—highland rainforests, transitional or ecotone between rainforest and lowland open forests and coastal lowland. A range of microhabitat strata were selected within each macrohabitat area such as swamps, old logging tracks, dirt roads, and creeks. Digging patterns were assessed by monitoring digging activity, at six-week intervals, on 195 line intercept transects (50 m). A digging index (proportion of transect disturbed) was established for each transect for each of the 10 recording events. Analysis assessed digging index patterns across seasons (wet and dry) and across microhabitat strata, within and between the three macrohabitat areas. An index for earthworm populations was also monitored to determine their association with the digging index.

Spatial and temporal patterns of feral pig digging activity were detected within the study area, specific microhabitats were found to have significantly higher digging activity overall and in specific seasons. Rainfall (soil moisture) appeared to be the major influence on these digging patterns; higher rates of diggings occurred in the early dry season and predominantly in moist microhabitats (swamp and creek microhabitats). The mean digging index over all strata within the three areas was 6% of the soil surface being recently disturbed by feral pigs.

Differences in the mean digging index between the three areas were apparent with the highland rainforests recording the highest digging index. This suggests either higher pig population densities in the highland areas or that digging is a more prominent foraging activity in this area. Differences in digging activity between the various

microhabitats were also observed in all of the three areas. For the highlands a significance preference in digging activity was found in the swamp stratum. Over all sampling times, swamps had significantly higher digging activity compared to all other strata and creeks had significantly higher digging activity than the ridge stratum. Overall ranking of strata preference was for highest digging index in swamp (19.3%), creek (9.7%) road (8.0%), track (3.0%), and the lowest preference for the forest floor (0.1%).

For the transitional area, the creek stratum also had significantly higher digging activity (8.5%) than the track stratum (0.6%). Digging activity was significantly associated with soil moisture in this creek stratum and tended to be strongly seasonal with higher digging activity occurring in the dry season. Digging activity increased in the creeks when soil moisture levels dropped sufficiently for earthworm populations to survive and repopulate the creek bed. Dropping water levels also exposed fresh soil surface and flood debris material which is attractive to foraging pigs.

No significant differences in overall digging activity were detected between the strata in the lowland area. Overall ranking of digging preference was for most diggings in the swamp (8.0%), creek (6.7%), tracks (4.9%), and the lowest preference for the woodland stratum (0.7%). This pattern of digging preferences in the moistest strata was similar to those observed in the highland and transitional areas.

Digging patterns appear to be influenced by the presence of microvariables which cause intense diggings in a small number of favorable microhabitats. Large areas of less favorable microhabitats tend to be associated with low levels of diggings.

Patterns of digging activity over time were also observed. In general, the highest digging activity tended to occur at the cessation of the wet season (start of the dry season). A distinct trend of increasing digging activity was evident as the soil started to dry out; this was very distinct in the table drains of the road strata. This trend may be due to the soil becoming more compacted when dry, which pigs find harder to penetrate, therefore drawing pigs to areas where soil is easier to dig such as the moist soils in the swamps or creeks. Another possibility is that earthworm populations increase when soil moisture levels are optimal, thus pigs may be increasing their digging activity to reach this high protein food source (French et al. 1957). Dry soil conditions tend to force worm populations to move to deeper soil horizons, beyond the reach of pig diggings (Lee 1985). Root mass also increase with optimal soil moisture levels (especially the fine feeder roots) and pigs may be digging more to reach this high energy food source.

The importance of earthworms in the diet of pigs is unknown in this region. The unavailability of earthworms in some strata during the dry season (earthworms move into deeper soil horizons) may encourage pigs to move to alternative microhabitats where conditions are more favorable. This may be linked to nutritional requirements, especially protein. Earthworms have been shown to be high in protein content (50 to 60%) (French et al. 1957). The effects of the seasonal fruiting cycle may also be a compounding factor. McIlroy (1993)

believed that nutrition may be the dominant factor influencing pig movements in this area.

The frequency of diggings within the microhabitats was also used to compare with the digging index. For the highlands a mean of 77% of transects were effected by some pig diggings for each sampling event (transitional area 58%; lowland area 85%). Over all the three areas, a mean of 59% of transects were effected by some new pig diggings at each sampling event.

Significant differences between mean frequency of diggings with the different strata were also detected for the highland and transitional area, no differences were detected for the lowland area. In the highland area, all strata had significantly higher frequency of digging occurrence than the ridge stratum. The transitional area reported the creek stratum had significantly higher frequency of diggings than the road stratum.

Temporal differences in frequency of diggings were also recorded. For the highland area significant differences between strata were detected in the dry season. For the transitional area significant differences in frequency of diggings between strata also occurred in the dry season. For the lowland area only one sampling event (dry season) recorded significant differences in frequency of diggings between strata. Thus it appears that feral pigs concentrate in the wetter microhabitats during the dry season and spread out evenly over all microhabitats during the wet season.

2. Ecological Impact of Diggings

The aim of this research was to quantify aspects of the ecology of feral pig diggings by using exclosures. The recovery of selected ecological parameters within the exclosures, protected from feral pig diggings, were compared with control plots not protected from pig diggings.

Feral pig proof exclosures (10 m x 10 m) were established in two microhabitats strata (wet areas and dry tracks) in the highland rainforest area only. For each microhabitat three sites were selected and for each site two replicated exclosures were established giving a total of 12 exclosures. An index of four ecological parameters within each exclosure were compared with two control plots established adjacent to each exclosure. The ecological parameters were seedling germination and establishment, above ground biomass, below ground biomass and earthworm biomass. Every exclosure was monitored at four to six weekly intervals over a two-year period. The exclosures have now been protected from feral pig impact for 3.5 years.

Feral pigs were shown to have a substantial impact on seedlings of rainforest tree species. The mean number of seedlings that were present within the exclosures over the two year sampling period was 36% (27% - dry stratum, 44% - wet stratum) higher than recorded in the control plots where feral pig digging activity had been occurring. Results also indicated that seedling germination and survival rates within the exclosures are 20% higher than the controls. No significant differences were detected in above ground biomass, below ground biomass, and earthworm biomass between the exclosures and the control plots.

3. Home Range and Seasonal Movement Patterns

The aim of this research was to develop a model of feral pig movements in relation to seasonal influences and to document home ranges and habitat usage in the coastal lowlands.

A total of 41 feral pigs (19 females and 22 males) were captured in traps and fitted with radio collars; 8 in the highlands, 19 in the transitional zone, and 14 in the lowlands. Collared pigs were located by ground methods (minimal one per month). Pigs, which could not be located from the ground (generally in the highland rainforests area), were located from aircraft.

No evidence of large-scale seasonal movements was evident for the pigs in the lowlands and the highlands. The transitional zone did record movements from the lowlands to the top of adjacent peaks (400 m); however, in all cases the pigs returned to the lowlands within a couple of days. The eight pigs in the highlands did move into the western rainforest/open forest ecotone (movement of 3 km) and spent a considerable amount of time there. Observation revealed that the pigs were using the riparian vegetation along streams coming out of the rainforests as travel corridors.

For the wet and dry season, individual pigs on the lowland and transitional areas were radio located at three hour intervals, continuously for 36 hours, and this was repeated each week for three weeks. A total of 11 feral pigs were collared, with sufficient data obtained for home range estimations on seven in the transitional zone and three in the lowland zones. In general, males have a larger mean home range (8.95 km²) than females (2.35 km²) and both have a larger mean home range in the dry season (9.94 km²) than the wet season (3.1 km²).

4. Biological Parameters

A trapping program was instigated in the three areas to capture feral pigs for biological investigations. A total of 317 pigs were captured over a two-year period. Ecological data on morphometrics, reproduction, diet, and growth rates were collected. In the lowland area a mark-tag-release program was used for population estimation.

Backdating age estimation of known age pigs (less than 36 months) to birth date has suggested a significant peak in births in January, the start of the wet season. Dietary items seen from gross examination include earthworms, fruits, centipedes, grass, roots and plant material. Growth rates and morphological information suggest feral pigs within this rainforest region have faster growth rates and are on average 10 to 20 kg heavier than feral pigs in the dry tropical regions. Preliminary data suggest a pig population of two per km² exists in the lowland areas.

DISCUSSION

Feral pigs have been identified as a major issue facing the management of the wet tropics World Heritage Area. However, the ecological effect of feral pig activity is difficult to quantify. Simple measurements of soil disturbance (diggings), is inadequate in understanding what "true" damage or otherwise is being imposed on the processes involved in the ecosystem. The main visual impact of feral pig damage is soil disturbance due to their searching behavior for plant roots and soil invertebrates.

Although animal signs do not necessarily correlate with population density or activity (Hone 1988), rooted ground has been used as an index of the impact of feral pigs on various environments.

Spatial and temporal patterns of feral pig digging activity were found within this study area for the two years of this study. In general, particular microhabitats were found to have significantly higher digging activity overall and at specific sampling times of the year. Rainfall (soil moisture) appeared to be the major influence on these digging patterns with higher rates of digging occurring, for all of the strata, generally in the early dry season and occurring predominantly in moist microhabitats (swamp and creek microhabitats).

The impact of pig diggings on the ecological processes within the rainforest is difficult to quantify over a short time frame. However, pig diggings appear to influence the survival of seedlings especially in the moist areas such as swamps and creeks. Although germinations were similar in dug areas to areas protected from diggings, the number of seedlings that were still alive was 36% higher when protected from pig diggings. Although rainforest seedlings have a naturally high attrition rate, an increase in the attrition rate by 36% when pig digging impacts are added, may have important ecological implications in the future.

The absence of seasonal movements in the feral pig population is contrary to the general community perception. Most landholders within the region believe that feral pigs migrate down from the highlands to the coastal lowlands in the dry season to forage on the ripening sugar cane and banana crops, and return to the highlands in the wet season when the sugar cane is harvested. The results of this study do not support that "seasonal migration" exists but is a perception caused by the feral pigs inhabiting the transitional area; the rainforest-crop boundary.

Home range studies suggest that feral pigs move greater distances and are more likely to forage further when food and water becomes scarce in the dry season. This increased movement activity would put them in greater contact with human activity especially during the sugar cane harvest season; humans encounter pigs more often. During the wet season, feral pigs are more sedentary, food and water are abundant, and human activity is minimized within the crops. Thus, human/pig interaction is lower in the wet season. This has led to the perception of more pigs around in the dry season compared to the wet and the community perception that these pigs had to come from somewhere; the highland rainforests.

The formation of the WHA is perceived by many members of the public as primarily responsible for the economic loss attributed to feral pigs, to the rural industries adjacent to the WHA. Pigs are an acknowledged pest of cane, bananas, and other small crops on the north tropical coast. However, the results of this study suggest that feral pigs adjacent to and in some cases living on landholders' properties are mainly responsible for this economic damage.

Control techniques on the WHA fringe need to be fully coordinated; poisoning, trapping, hunting, and fencing techniques can all be implemented if the activities

are integrated into a control strategy. For example, large scale trapping programs can be established in environmental sensitive areas, or feral pig concentration areas where landholder groups are available to interact with the program. Hunting by licensed hunters would be suited to low pig population areas or in areas inaccessible to other control techniques. Fencing can be employed in high return cropping or intensive agriculture situations where the cost is warranted. Fencing may also be an option in small sensitive conservation areas or where rare or endangered species are localized, although the impact on other species needs to be considered.

The implementation of a feral pig management strategy must rely on a clear understanding of the severity of ecological impact of pig diggings on WHA values and also the level of population control required to protect these values. Additional research information is required on "best practice" control techniques to develop efficient, cost effective, and specific population control. A sound management plan needs to coordinate, monitor, evaluate, and continually evolve with developing strategic directions.

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