

BEHAVIOUR IN CAPTIVE INDIVIDUALS OF THE DASYURID
MARSUPIAL *PLANIGALE MACULATA* (GOULD 1851)

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ABSTRACT

Common Planigales (*Planigale maculata*) from coastal Queensland and New South Wales were maintained for three years in captivity. They were found to have relatively poor eyesight compensated by acute senses of hearing and smell. Their activity phases consisted of periods of intense activity followed by torpor-like rest periods. They constructed ball-shaped compact nests only when with young and at other times occupied small depressions under grass, logs or rocks. Their postures were similar to those seen in other dasyurids, although a number of grooming actions involving the cleaning of vibrissae, pinnae, or matted tail hairs, appear to be uncommon in other genera. Animals defaecated and urinated both deliberately and randomly throughout their enclosures. They also rubbed their cloacas and sternums on objects in the cage. They preyed voraciously upon insects and small vertebrates and exhibited a 'fanning' response to mucous-covered or unpalatable prey. At least five specific vocal calls were made, females being more vocal than males. Aggression between animals was most commonly observed during a female's oestrus and also after food thieving, but threat and appeasement calls usually inhibited serious fighting. Oestrus females attracted potential mates by calling for a period of two or three days. Copulation lasted approximately two hours, and was characterised by males using a neck grip and 'scratching' with the hind feet throughout the entire copulatory procedure. Females were generally passive throughout copulation. The gestation period was approximately twenty days, the young first detached from the teats between twenty-four and twenty-eight days and were independent at seventy-two days.

It is proposed that wild Common Planigales are most probably polyoestrus and socially intolerant.

Small dasyurids studied in detail in captivity include: *Sminthopsis crassicaudata* [Ewer 1968], *Dasyercus cristicauda* [Ewer 1969], *Dasyuroides byrnei* [Aslin 1974], *Antechinus stuartii* [Marlow 1961; Braithwaite 1970], *Dasyercus cristicauda* and *Dasyuroides byrnei* [Sorenson 1970], *Dasyercus cristicauda* [Mitchener 1969], and *Dasyuroides byrnei* [Eisenberg and Leyhausen 1972].

The only comparable studies of species of *Planigale*, are some general observations of captive specimens of *P. ingrami* (McKay 1974), recordings of particular aspects of reproduction in *Planigale maculata sinualis* (Aslin 1975), and the emergence of pouch young in individuals of *P. maculata* (Morrison 1975). Other reports of behaviour and reproduction in Planigales (e.g. Fleay 1965, 1967; Van Deusen 1969) have been confused by uncertainty in specific identifications (Archer 1976).

This study reports behaviour in individuals of *Planigale maculata maculata* (Plate 1a) from various east coast Australian localities. Identifications have been based on the revision of the genus by Archer (1976). *Planigale maculata* (the Common Planigale) is a non-arid-adapted species inhabiting grasslands (e.g. *Imperata*) associated with a variety of habitat types. It is common east of the Great Dividing Range in Queensland. Because of their aversion to standard mammal trapping techniques (Van Deusen 1969), their ecology and behaviour in the wild is undocumented. The present study on captive animals was undertaken to provide preliminary information on aspects of behaviour which may in the future be checked in wild situations.

METHODS AND STOCK

Live Common Planigales were obtained from Condong in northern New South Wales and

Gympie, Townsville, Ingham and Coen in Queensland. These animals were studied from 1973 to 1976 with most of the detailed observations taking place during 1975. Animals were housed individually or in pairs in glass-fronted cages measuring 90 × 100 × 80 cm. These cages contained numerous hiding places and pathways formed by hollow logs, tree boughs, rocks, grasses, and litter on a dirt and sand floor. They were left uncleaned for as long as possible in order to minimise disturbance. The animals were studied under either an eight watt fluorescent tube covered with blue cellophane, a red forty watt bulb, or a combination of both. Under these conditions the animals did not appear to register disturbance while being quietly observed. There was no reversal of light, and animals were subject to Brisbane ambient temperatures throughout the study.

A typical weekly diet for each Planigale consisted of: one or two baby House mice four times per week; mealworms and other insects four times per week; and meat mixture (minced meats, brawn, grated cheese, vitamin E oil, hard boiled egg, ground dog kibble) six times per week. Water was always available in small dishes and was supplemented with Pentavite Infant Drops once weekly.

RESULTS OF OBSERVATIONS

SENSORY RESPONSES

The Common Planigale has small eyes compared with many other dasyurids e.g. *Sminthopsis* and *Dasyuroides*. In contrast to the senses of hearing and olfaction, sight appeared to be of minor importance. During scuffles with prey, Planigales were unable to relocate dropped food by sight. It would seem that in the absence of sufficient olfactory or auditory clues, dynamic visual signals are necessary before animals respond.

In *Antechinus godmani* natural disease can cause blindness (pers. obs.). The ease with which blind individuals move around the rainforest floor, catch insects, and enter traps (pers. obs.) suggests that in this small-eyed *Antechinus*, eyesight is not vital. This supports the supposition that eyesight in the Common Planigale is also a non vital sense.

Olfactory and auditory perceptions appeared to be well developed although it was not always possible to establish which stimulus animals were responding to, because sniffing nearly always accompanied auditory perception.

When meat was introduced into the cage with Common Planigales, the animals left their nests

where they were sleeping, sniffed the air, jerked the head up and down rotating it at the same time, and followed the scent to its source. This sniffing behaviour is much more developed in Common Planigales than in spp. of *Sminthopsis* (pers. obs.). Pieces of handrubbed string or paper brought sleeping animals from their holes often within fifteen seconds after introduction. Some scents, and in particular human breath, disturbed the animals. If subjected to slow human breathing from about 30 cm above their nests, the animals would flee to various hiding places in the cage, emitting a wheezy call similar to the 'possession call' (described later).

They responded to gentle scratching on their cage walls by tracking the sound to its source. Insects moving in the cage were always investigated and tracked down prior to the investigation of similar dead insects, and they dug up litter and soil to reach live insects they detected underground.

It seems that olfaction and hearing are acute over a longer range than sight. Close range activities involving sight are probably aided by stimuli received through the very long vibrissae.

ACTIVITY RHYTHM

Common Planigales emerged at, or slightly before dusk. In some cases they emerged up to two hours before sunset. Activity continued throughout the night, interspersed with rest periods.

During the day animals slept in regular sleeping sites: in nests under logs, rocks, or in the bases of grass clumps.

During the night, rest periods were not confined to regular sleeping nests but often occurred in diverse areas around the cage. Male Planigales often rested on branch tops or lodged themselves between a branch and the cage wall. The actual time of night that animals returned to their nest was variable.

Reversed light was not set up, and few all night watches were kept. One is summarized in Figure 1. Total time out of nests varied from 9 hours in a maturing male to 1.5 hours in an adult female. Feeding and drinking times usually took place soon after emergence at night, again during the subsequent activity periods, and again before dawn in the last activity phase. The Planigales rarely extended their activities beyond sunrise. Most animals returned to nests at least one to two hours before sunrise. This contrasts with individuals of *Sminthopsis macroura* which often extend their early morning phases up to an hour or more after sunrise (pers. obs.).

During the day animals were often seen grooming themselves, yawning and 'sleeping'. In describing the behaviour of *Planigale ingrami*, McKay (1974, p. 5) states '... they alternate between periods of intense activity and periods of quiescence. Within the resting periods there are times when respiratory movements are rapid and shorter periods of slow respiration, presumably sleep'. For the purpose of this paper 'sleeping' was regarded as a marked reduction in breathing rate and body activity, whether the eyes were open or closed. Normal alert breathing rate in adults is approximately 350 breaths (intakes) per minute,

whereas during 'sleep', this rate drops to as low as 80 per minute, (all counts were made at 22° C). This phase of very low breath rate may be torpor.

During nocturnal rests animals yawned, groomed and slept, but because they were often hidden from view it was not possible to quantify these aspects of behaviour.

NESTING ACTIVITIES

The Planigales did not dig tunnels, although superficial 'tunnels' were formed by pushing through surface material such as leaf litter and

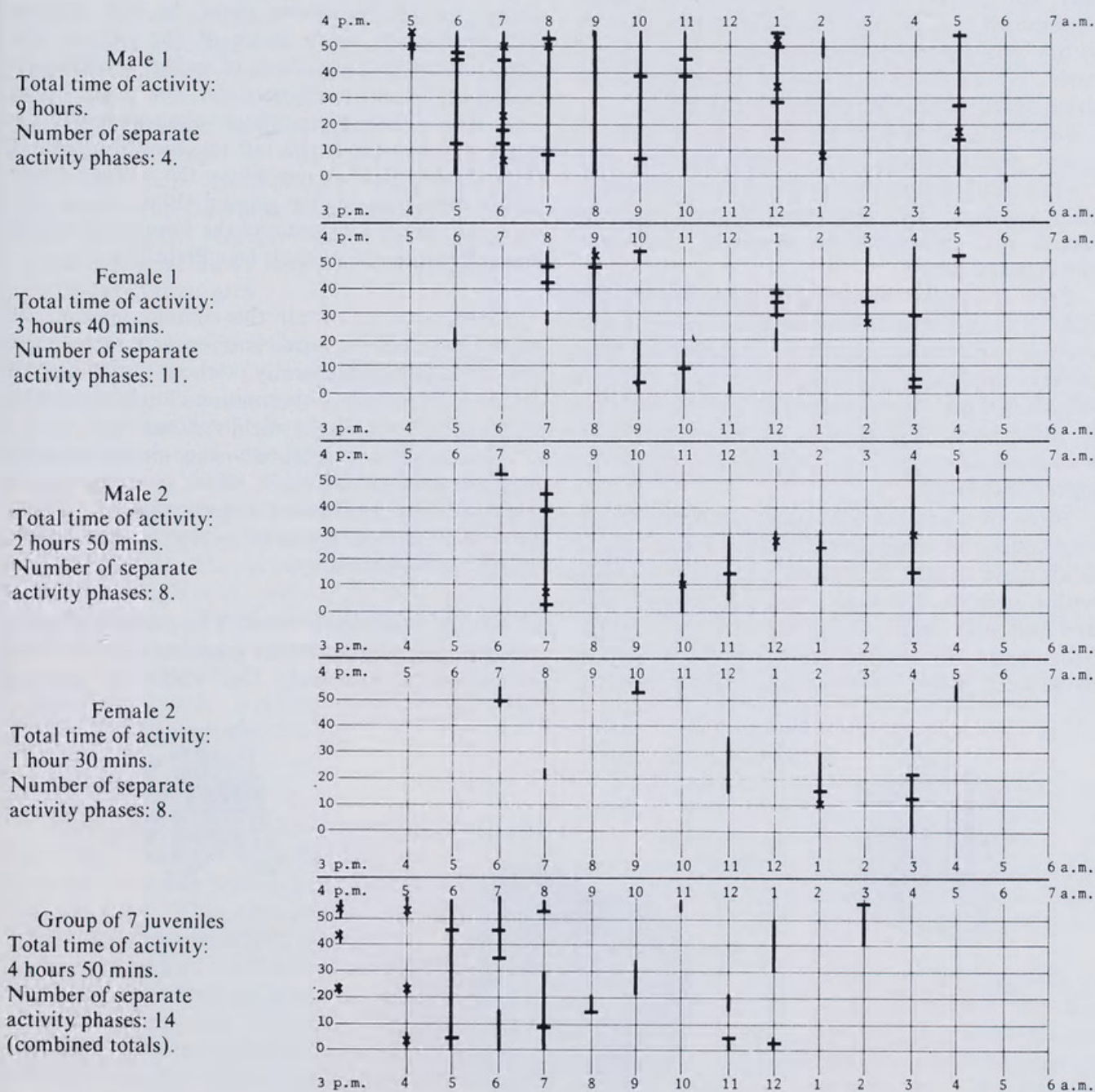


FIG. 1: Activity rhythms for Common Planigales, 6 June 1975. x = times at which animals drank; — = times at which animals fed.

grass-cuttings. These often terminated in small cup-like depressions (nests) in which they slept. Heinsohn (1970) reports a captive male Ingram's Planigale (*P. ingrami*) pushing through grass and forming a 'covered runway' at the end of which was a hollow chamber used for nesting. The same type of tunnelling has been recorded for the Dusky Marsupial Mouse (*Antechinus swainsonii*) (Van Dyck and Ogilvie 1977).

Adult females with pouch young carried nesting material including grass, leaves and insect wings, in order to construct compact 'tennis-ball shaped' nests in hollow logs. Fleay (1965, p. 196) records that his female Planigale, with seven young, maintained '... a small neat saucer-shaped nest of dry grass beneath concave shells of wood and bark'. He describes one nest as being similar to those made by Blue Wrens (*Malurus* spp.).

Juvenile Common Planigales, after leaving the pouch permanently, always slept together in a crude saucer-shaped nest originally constructed by their mother. This nest they shaped with the mouth and attempted to maintain with grass cuttings and leaves.

Each individual in unmated pairs had its own nest in a separate corner of the cage and each showed consistent agonistic behaviour when another individual appeared at its nest entrance. All diurnal and most nocturnal sleeping was done in these nests. The animals regularly took large prey back to within a few centimetres of the nest entrance to eat.

Nests of Common Planigales examined in the wild contained single animals. On one occasion an adult male caught in Ingham was found sleeping with a juvenile *Melomys burtoni* in a small grass and leaf nest under corrugated iron (pers. obs.). Most nests constructed under sheets of iron or wood were simple tea-cup-like structures made of

leaves and grass, and lined with insect wings and small leaves.

Mated pairs in captivity consistently slept together under or in small logs and rarely changed the position of their nests.

POSTURES AND EXPRESSIONS

The terminology used here is that given by Ewer (1968).

BIPEDAL STANCE: This is a common dasyurid posture (also called 'Investigatory Upright' by Aslin 1974) and occurs when animals investigate sounds or objects above them. In this position Planigales rest much more of the tail on the ground than do individuals of either *Sminthopsis macroura* or *S. crassicaudata*. The posture can vary from a vertical upright position with only the hind toes and tip of the tail touching the ground, to a semi-bipedal stance where the whole surface of the foot rests on the ground (Plate 1b-c). The ears are turned forward and the forepaws are held out in front of the animals (see Plate 1b).

INDECISION ALERT: In this common posture the ears are turned forward, one forepaw raised, and the tail held horizontally without touching the ground (Plate 1d). This position closely resembles that seen in individuals of *Antechinus* spp.

The position of the ears can change rapidly from a forward direction when investigating, to tightly folded back when the animals are subject to sudden noises, aggression from other animals, or when attacking prey.

EATING AND GROOMING: The animals adopt a squatting-on-the-haunches position with the ears turned back and out. The whole of the tail



FIG. 2: Common Planigale postures. a, cleaning vibrissae; b, sleeping; c, cleaning an ear.

contacts the ground and the hind legs are stretched out in front. This posture provides considerable stability (Plate 1e). Both forepaws are generally used in holding even very small prey.

SLEEPING: Common Planigales adopted a variety of 'tight' sleeping positions with the limbs usually kept close to the body. When pairs slept together they often lay over one another (Fig. 2b). Juveniles slept on top of and across one another, but generally all animals lay with the dorsal side up.

'FREEZING': Planigales frequently 'froze' after noise or disturbance. They would remain completely motionless for as long as two minutes. Usually another sound or movement 'snapped them out'. They then continued with the activity engaged in before the disturbance.

This 'freezing' is very common in other dasyurids, e.g. *Sminthopsis* spp., *Phascogale tapoatafa* and *Dasyurus hallucatus* (Fleay 1962), and probably protects them from nocturnal predators (e.g. owls) that rely on movement for detection of their prey.

GAITS: Common Planigales are splay-footed (their hind feet point out and away from the sides of the body). Leg sequence during walking is right front, left rear, left front, right rear. Much activity involves running, or hurdling over objects, as well as jumps of up to 10–15 cm between branches and rocks. The hind legs often remain together during hops from a slightly higher position to a lower one, or over leaves. This is reminiscent of the gait in sick individuals of *S. murina* and *S. crassicaudata*. All Common Planigales hold the tail high when walking or running so that no part of it comes in contact with the ground. Characteristic movements while carrying prey are discussed under 'Feeding behaviour'.

ARBOREAL ACTIVITIES

Planigales appear well adapted for arboreal activities (Plate 1f). A young male spent 30% of a one-hour evening activity phase amongst branches in his cage. This accounts for most time not otherwise spent in eating, grooming, or running on an exercise wheel. Both males and females actively and expertly climb using the same gait and speed in descending and ascending as they use on ground. After eating large meals, some individuals climbed onto branches in order to groom or rest.

The palm of the manus and the sole of the pes have enlarged striated pads aiding in arboreal

activities. The hind limbs are turned out, and while walking on small twigs (2–4 mm diam.) the toes of the hind feet wrap completely around the twig.

EXPLORATORY BEHAVIOUR

A cloth bag saturated with House mouse urine was introduced by a string into the cage. Planigales responded with the investigatory sniffing of the air; a slow approach; an inspection and sometimes a clawing of the bag; and finally ignored it.

Planigales were cautious of unfamiliar food bowls placed in the cage. The slightest noise from other animals in the cage would cause them to instantly abort an initial approach to an unfamiliar item.

Individual differences in exploratory behaviour are high, and male Planigales appear to take greater initiative in investigation of new objects and are less wary of new situations (also see later in regard to olfactory signals), than females.

GROOMING

Mutual grooming between adult individuals of *Planigale maculata* was never observed.

During one all-night watch, hourly records were made of the total time that an adult male spent grooming. During the thirteen-hour period, 19 minutes 35 seconds (19:35) were spent in grooming and there were 34 separate periods of grooming activity. The times spent in grooming for each hour from 4 p.m. to 6 a.m. were: 1:20, 2:00, 4:55, 1:05, 0:20, 2:15, 2:25, 0:00, 3:25, 0:45, 0:00, 0:00, 2:05, 0:00.

Animals were also observed grooming during the day, and before emerging at night.

Grooming invariably followed mouse meals and generally followed those of mealworms. Some elements of a typical grooming sequence observed after eating consisted of:

(1) Licking the paws together (6–10 sec) and working them along under the snout together, the hands being drawn over the whiskers; the hands work in opposition around the snout, along under the chin, down from the eye to the mouth, behind the ears, and back over the closed eyes to the mouth (20 sec).

(2) Licking the upper arm of forefeet while the forefeet stretch downward; the tongue then licks below the animal's chin on the chest while the neck is stretched; the animal holds the right leg with the left paw and licks the right forearm, before reversing the posture in order to clean the left leg (15 sec).

(3) Cleaning the belly and body by licking the fur that is held between or below the forepaws as they pull the skin to the mouth and simultaneously comb the fur after licking. The animal then licks and nibbles the cloacal region and testes (30 sec).

(4) Left hind foot scratches between the ears and is returned to the mouth where it is licked. It then scratches under the mouth and is again returned to the mouth to be licked. This process of scratching and returning the paw to the mouth continues — flank, to mouth; neck, mouth; left ear, mouth; belly, mouth; middle of the back and under the flank, mouth; behind the left ear and under the front foot, mouth; left ear, mouth (30 sec).

Grooming lasted up to three minutes and generally started with face and paw cleaning, progressed through forearm, body and tail cleaning, and ended with the body being scratched with the hind leg.

The occasional scratch with the hind foot generally resulted in the foot being licked. When the interior of the pouch was cleaned, it was not forced open with the forepaws but lay open by muscular relaxation.

Some grooming actions seen in these Common Planigales have not been noticed in other related dasyurids such as species of *Sminthopsis*: (1) straightening of matted hairs on the tail by using the upper incisors to comb the tail hairs; (2) cleaning the vibrissae using simultaneous action of the left forefoot to left vibrissae and right forefoot to right vibrissae (Fig. 2a). The vibrissae are pulled through the closed paws; (3) slowly running a single pinna in sandwich fashion between the two forepaws, licking the paws and repeating (Fig. 2c).

OTHER MOVEMENTS: Shaking of the body was not observed (this is common in individuals of *S. crassicaudata* and *D. byrnei*).

Sandbathing and rolling was never observed, although facilities existed for these activities.

Stretching occurred mainly on emergence from nests. Forelegs extended singly with wide-stretched fingers and then back legs were stretched together with a general lowering of the body.

Yawning occurred after sleeping; when awake during the day; or while stretching.

DEFAECATION AND MICTURITION

Animals did not soil their nests and 'deliberate and casual' defaecation and micturition took place. ('Deliberate' refers to the regular deposition

of faeces or urine in a selected spot whereas 'casual' deposition takes place at random throughout the enclosure; see Ewer 1968).

In unmated pairs, deliberate defaecation occurred in each corner of the cage nearest to the animal's day nest and about 10 cm away from the next entrance. The cloaca was generally wiped on the substrate after defaecation. Micturition was only observed to occur in association with defaecation. Following deliberate and casual defaecation the faeces were usually smelt and then ignored. The average toilet was five drops of urine followed by a 1 cm dropping.

Adult mated pairs and pregnant females deliberately deposited faeces in two corners of the cage. The pregnant females mostly used the corner nearest the nest (<10 cm from it). This behaviour continued through lactation. Juvenile animals made a communal pile in one corner and casual defaecation was common.

It would also seem that Common Planigales use urine and faeces in scent marking.

If an individual had difficulty in evacuating a faecal pellet from its cloaca by rubbing it along the ground, it picked the pellet out with its incisors and either flicked it away with a sudden toss of its head, or brushed it from its mouth with its paw.

FEEDING BEHAVIOUR

Foraging took place with forepaws digging alternately on either side of the head, as the nose thrust into areas where prey was possibly concealed. In locating prey, the animals either ran around the enclosure, stopping to investigate sounds or smells, or they sat quietly — mainly near branches, nests, or cover — and responded quickly to any sounds.

Small innocuous prey such as mealworms were normally grabbed with the incisors and immediately transferred to the cheek teeth with the use of the forepaws. However when taking mealworms from a dish, the animals often reached down and snatched the mealworm out with the hand. When stealing food from another animal the forepaw was generally used to snatch food from the owner. When taking mealworms from my hand, a female always smelt the worm, grabbed it, and ran off to the eating corner.

Common Planigales usually adopted one of two eating postures: a 'secure' eating posture (shown in Plate 1e and g) when unharassed and in a suitably private spot; or an 'insecure' position with one forepaw on the ground when eating in haste or when being harassed by other animals.

When in possession of food and under threat Common Planigales uttered a 'possession call

(described later) and ran to a 'safe' spot in the cage with the food, using a hopping gait with head held high, reminiscent of that used by most rodents when retrieving young. (I have not seen this gait in individuals of the genus *Sminthopsis*). The animals adopted a hunched eating posture and used the hands to transfer the worm from one side of the mouth to the other. While one hand held the food in the mouth, the other made grabbing movements and 'air-clutches' near the mouth, corresponding with those of the hand that was holding the food. It takes c. 300 chews and 1.25 minutes to eat a fully grown mealworm larva. No particular end is started at and no 'killing bites' are administered. As in most other dasyurids, hands were used extensively for grabbing and restraining flying prey such as moths and beetles.

Large lumps of meat-mix held in the incisors were broken into small pieces by quick sideways flicks of the head. These small pieces were then searched out and eaten.

Very small grasshoppers (<2 cm) were quickly killed by bites into the thorax and head and then eaten entirely except for the wings.

In dealing with larger grasshoppers (<7.5 cm), adults closed their eyes on contact with the insect. They did not stalk with closed eyes as do individuals of *Sminthopsis macroura*. Attacks were generally ineffectively directed at the large hind legs although one female consistently pushed her snout up between the abdomen and wings and bit into the soft abdomen. Persistent biting prevented the grasshopper's escape and it was ultimately injured or worn down by the perseverance of the planigale rather than being quickly killed. The abdomen was eaten and the head, thorax and wings discarded. Young Planigales also closed their eyes on contact with grasshoppers but were unable to kill those over 5 cm, which were usually sniffed and ignored.

Inexperienced Planigales were generally very poor killers of mouse pups. After grabbing the pup, they 'hopped' with it to an appropriate spot and commenced eating it at any part of its body, often from the hind feet or tail. In this way the pup was often still squirming and squeaking three or four minutes after the initial attack. It generally took a Planigale about fifteen to twenty minutes to devour a pup, and considering the relative sizes of the two animals, this reflects the incredible appetite of the Common Planigale (see Plate 1g for comparisons of size).

Juvenile animals were at first very poor killers and although their jaws were strong enough to crush the skull, they often bit at random, chewed

on limbs, and left mouse pups maimed and bleeding. Their technique improved with experience. The most efficient killers were old adults, which always administered neck and head bites, and increased biting if the mouse pup squealed. This ensured quick deaths and was followed by the pup being eaten from the head-end first.

Food stealing was prevalent and resented by other individuals. Thieves snatched with paws and often made an open attack on the owner of the food. Juveniles were observed diving for the owner's neck and wrestling with him without reference to the prey. Attacks of stealing were generally met with threat calls and 'boxing', or the owner would utter the possession call and run away with the food. Some of the worst fights observed in juveniles occurred over thieving.

A Brown-orange Bug (*Musgraveia sulciventris* (Stal)), was introduced into a cage. It was sniffed out and immediately bitten by a female Common Planigale. After being sprayed by the insect she retreated and rubbed her chin on the ground while walking in a circle. After two more mouth attacks, the forepaws were used to administer attacks, scratching the bug towards itself using alternate paws. During the attack the female vigorously bit a leaf lying nearby. After being sprayed in the eye, she rubbed that side of the head in a circle on the ground. She continued to make paw attacks accompanied by 'fanning' (rapid lateral movements of both paws — reminiscent of hands clapping, but without ever meeting). This behaviour has been seen in the Darling Downs Dunnart (*Sminthopsis macroura*) when dealing with witchety grubs, and in Ingram's Planigale (*Planigale ingrami*) when trying to eat worms (pers. obs.). It was also seen in Common Planigales when the animal had trodden on and squashed ants. The purpose of this behaviour is not known, but it is always associated with irritating substances such as mucous on prey. Eventually the female dislodged the bug's head, discarded it, and ate the body.

VOCALIZATION

Common Planigales have an audible repertoire of at least five calls:

- (1) A 'possession-call', a soft 'rhitt rhitt rhitt . . . with each 'rhitt' repeated about three times per second, was uttered when retreating with food, even if unchallenged by potential thieves. This often aroused sleeping animals who came out to look for the food.
- (2) The threat call of the female consisted of a sharp 'ssstt' and was in defence of space or in

attack. The male call consisted of a soft 'tit tit tit...' uttered when attacking and retreating.

- (3) When struggling with large grasshoppers and when breathed on by humans, Common Planigales uttered a soft, short, 'sss sss sss...' each 'sss' of which is repeated about four times per second.
- (4) A 'mate-attracting' call was uttered by females approximately three days before mating. This is a wheezy loud 'tsz tsz' uttered while sitting high on a rock or log. This was sometimes answered by the male with similar call.
- (5) An appeasement call was generally uttered by a male while being attacked by a female. This call resembled 'fitt zitt' and 'fitt fitt'. The eyes were usually closed.

OLFACTORY SIGNALS

Common Planigales appear to recognise each other by mouth smell (Ewer 1968, noticed this for the Common Fat-tailed Dunnart (*Sminthopsis crassicaudata*). Two animals approach one another front-on, with ears pressed back, each sniffing the other's mouth along the lower jaw. One may open its mouth slightly and utter a threat call or both may ignore each other. Sniffing occurred more frequently in Common Planigale encounters than in encounters between Darling Downs Dunnarts (*Smithopsis macroura*) under similar conditions (pers. obs.).

Individuals of *S. macroura* react to foreign odours (pieces of string or paper rubbed on the hand or body) by dropping urine, rubbing the cloaca, depositing faeces upon, or spreading saliva near the source of the odour. Common Planigales, however, sniffed the string and paper and ignored it (except for one young female who, after sniffing the paper, grabbed it in her mouth, 'hopped' with head in the air to her usual eating corner where she then ignored it).

STERNAL GLAND MARKING

In early June, young males which had been born the previous September began actively rubbing the chin and chest over food bowls, leaves, branches, and their exercise wheels. During the second hour of an eight-hour activity phase one individual marked 39 times.

A leaf marked by a young male was placed in a cage containing a pair of adults. The adult female sniffed and immediately 'attacked' it, bit it for one or two seconds, sniffed it for forty-five seconds, then bit it again for a few seconds; after another five minutes of mild interest she finally ignored it.

The same leaf was sniffed and ignored by the adult male. Alternately, grass transferred from an adult pair's cage to an unmated pair's cage induced sniffing by the young male and extra marking of food bowls, but after that the grass was ignored.

Braithwaite (1973) notes that in the Brown Antechinus (*Antechinus stuartii*) males and females move in June to areas where they usually remain until death. During this month the sternal gland of males increases in size. Marking activity increases, and testosterone levels rise. The testes also increase in size, and aggression between males becomes greater.

AGGRESSION

In all instances, when an unfamiliar female (either in or out of oestrus) was placed in an adult male's cage, it was the female who initiated threats, bites, and vocalization. In most cases the male would turn the head exposing the chin, raise the forepaw, and accept bites to the neck and face by the female, and 'retaliate' only by scratching at her. Females would generally sniff the mouth of the male and direct bites around his face. During this activity females' mouths were opened and they kept calling. The ears of both animals would be tightly folded against the head and the eyes half closed. The male would follow the female and sniff her cloaca, which usually either brought her swinging around to direct a few more bites at the male, or sent her scurrying off.

During 'copulatory fights' where the male made advances to an oestrus female, the two would have sparring confrontations lasting up to a few minutes each time. In such instances the female would make consistent quick bites at the male, often catching him briefly on the nose. Her eyes and mouth would remain wide open while his eyes would stay squinted. Eighty such 'jabs' by the female sometimes occurred within a single minute. These appeared to be 'soft-mouthed' until the male's advances become more intense, when the female often bit the male hard on the nose. At this time the male would utter a constant appeasement call (see previously). The most interesting feature of these confrontations is the definite inhibition on the male's part to bite the female or to force his attentions. Morrison (1975) records similar dominance by the female.

Little aggression was seen in unmated pairs before June. The male would frequently displace the female from the exercise wheel with no bodily contact. If the male poked his head into the females' nest-hole she would utter a few threat

calls, and he would slowly enter after initial mouth smelling.

From the beginning of June the young males' aggression increased. One frequently attacked the female in the activity wheel and actively sought her out during the first few hours after emergence at night. When she ran from the wheel the male often ran after her, dived onto her back, bowled her over, and tried to bite her neck. Alternatively he would chase and grab her and then bite her tail. In most cases a few loud threat calls uttered by the female would cause the male to retreat. Braithwaite (1973) suggests that in the Brown Antechinus, *A. stuartii*, the endogenously arisen appetitive behaviour for aggression results from variation in corticosteroid production. The same probably applies to aggression in maturing male Common Planigales.

Flights were also seen in juveniles (as described above for food thieving). The animals frequently rolled around while limb-locked. Most bites were directed to the back of the head or neck.

Tail thrashing in adult males was common after scuffles. This behaviour is very common in many kinds of dasyurids and appears to be a form of displacement activity.

REPRODUCTIVE BEHAVIOUR

Observations were recorded from the matings of three pairs of Common Planigales (23 Aug. 1974, 19 Nov. 1974, 6 Jan. 1975) and two raised litters.

BIRTH TIMES: Fleay (1965) records summer births for his Planigales, but Aslin (1975) records breeding in individuals of *Planigale maculata sinualis* in all seasons. Juveniles of *P. maculata maculata* in the Queensland Museum collections were measured, the dates of their captures recorded, and an approximate date of birth assigned to each individual or litter (this date is assumed from comparisons with series of captive bred juveniles of *Planigale maculata sinualis* preserved in spirit in the Queensland Museum). Probable birth dates, presented in Table 1, suggest that *P. maculata maculata* also reproduces in all seasons.

Lactating females J21325, J8244, J3093 were captured on 9 Sep., 20 Feb., 27 Nov., respectively.

Although births may occur throughout the year in Queensland and northern New South Wales, there is insufficient data available to predict in which seasons (if any) most litters are produced. This is further complicated by the possibility that preferences in breeding seasons may vary with latitude. It is also not known if individuals of this

subspecies are polyoestrus. Animals held in captivity bred only once during the year.

MATE CALLING: At the onset of oestrus, females usually became more active, calling persistently throughout the night. Typically females stopped running, lifted their heads and uttered a wheezy, husky but loud 'tsz' call, and then ran off again. More often they called from a high vantage point in the cage. At this time their cloacas appeared to be swollen and they actively rubbed sternum and cloaca on objects in the cage, in particular on such items as clean food trays.

This activity is almost identical to that seen in the Common Dunnart (*Sminthopsis murina*) which, when without a mate, may call for a period of approximately ten days (pers. obs.). By about the fifth day, Common Dunnart females even call throughout the day and the call changes to a succession of sharp 'ts-ts-ts-ts' sounds. By the sixth and seventh days this activity slows down and the calls are made from sitting positions on, for example, favourite rocks in the cage.

TABLE 1: PROBABLE MONTHS OF BIRTHS OF JUVENILE COMMON PLANIGALES.

Registration No. (QM) and sex	Head-Body Length (mm)	Capture Date	Probable month of births
J22041 undet.	8	12 January	January
J4268 ♂	16	9 March*	February
J8070 ♂	47	26 June*	March
J4534 ♀	50	23 July*	April
J21324 undet.	45	11 October	July
J21326 ♂	46	(one litter)	
J21327 ♂	41		
J21328 ♂	41		
J21330 ♂	51		
J17621 ♂	17	September	August
J7559 undet.	7	14 September*	September
J578 ♂	11	26 November*	October
J17914 undet.	9	26 November	November
J3345 undet.	10	20 November	November

* Date of entry into register, probably close to capture date.

Male Common Planigales became more interested in the females at the onset of oestrus and made frequent unsuccessful low-key attempts to mount. Although the females' behaviour at this time was directed towards mate finding, they at no time accepted copulation passively, but fought with and hid from pursuing males. On the second day of calling, the males' interest was more aroused. They sniffed the females' cloacas, and between unsuccessful attempts to copulate, they licked their erect penises and rubbed and thrust them on rocks and other objects in the cage. Males made leaps of up to 25 cm in attempts to spring on to escaping females.

COPULATION: When males finally caught females, they gripped them very firmly behind the ribs and in front of the hind legs with their forefeet and then bit the skin between the ears, high on the females' necks.

Ewer (1968) notes no use made of a neck bite by male Common Fat-tailed Dunnarts (*Sminthopsis crassicaudata*). The behaviour however is common to many species of *Antechinus* (Marlow 1961) and is common in initial stages of copulation in the Kowarie (*Dasyuroide byrnei*) (Aslin 1874). Archer (1974) notes use of the neck grip in the Western Native Quoll (*Dasyurus geoffroii*) and cites the observation of Miss V. Bristow that the necks of female Western Native Quolls become swollen when they are reproductively receptive.

In Common Planigale males, the penis always erected very quickly and underwent an independent 'thrashing' motion until in contact with the female's cloaca. After about two minutes of active copulation males began a hind-foot 'scratching' that resembled a standing dog trying to scratch its belly with its hind foot. Marlow (1961) termed this a 'scratching reflex' after observing it in the Brown Antechinus (*Antechinus stuartii*).

This behaviour has been noted by Archer (1974) in *Dasyurus geoffroii*. Aslin (1975, p. 200) records a male *Dasyuroides byrnei* 'scratching the female's cloacal area with his hind leg'.

Scratching in Common Planigales alternated from left to right foot every second, and each foot 'scratched' about four times per second. The activity appeared continuously throughout the copulatory sequence and after about one and a half hours the scratching appeared to be directed at the neck of the scrotum, so that the leg did not come to rest on the ground but on the top of the scrotum. The male's forefeet constantly grabbed and clutched the female's skin. Any resistance on the part of the female was now countered by a

male taking a bigger mouthful of the female's neck.

After 15 to 20 minutes, males made a series (up to 30) of very powerful thrusts, which often twisted the pair in circles or caused them to topple over on their sides. Marlow (1961) records Brown Antechinuses (*Antechinus stuartii*) rolling over after a single coital thrust made by the males.

Males frequently lifted up females and turned them in the opposite direction. Sometimes the males would give the female's head a vigorous lateral shaking every 5 to 10 seconds, taking fresh and deeper bites of the neck at every shake.

During most of the copulation period, the females remained so passive that they appeared dead. They remained motionless with eyes closed, and only occasionally struggled or dragged the male around. Their only consistent activity was a slight upward jerking of the head which occurred approximately once every two seconds throughout the sequence. Copulation usually ended with a struggle. The two separated and both appeared very active with no visible signs of fatigue. Females showed no sign of damage from the male's neck grip. In three separate instances, copulation lasted 1.75, 2.5, and 2 hours respectively.

The males showed continued interest in the females for one or two days following copulation, and sometimes copulated again during this time. After these two days no more sexual interest was shown. During the two days following copulation females became increasingly aggressive towards males. It is probable that in the wild this aggression would drive males away. For this reason the male was removed from the cage about a week after copulation.

GROWTH OF YOUNG: Births of the young occurred after gestation periods of twenty and twenty-one days respectively.

On about the sixteenth day after birth, females constructed a tight grass-ball nest in a log.

By the seventeenth day, the pouch no longer always remained tightly closed, and a rear view revealed four young, positioned anteroposteriorly inside the pouch. By this stage the pouch had greatly enlarged, and a thin flap of muscular skin had spread out over the young and almost covered them, except for the posterior end near the cloaca. Females frequently licked the young in the pouch by relaxing the pouch muscles, sitting in a squatting position with the head between the legs, and pushing in with the snout. After fright, any excreta spilt on the young was licked off. Seventeen-day young are covered with minute

transparent hairs; the ears are pressed down and flat; the eyes are undeveloped, but the limbs and tails are well-developed; the skin on the back is grey to black but pink in other areas. Their breathing rate was approximately 148 intakes per minute.

At approximately seventeen days after birth the diets of the females changed. They rejected mouse pups and ate only live insect food. They responded to a human finger near the glass cage wall with partly opened mouth and a wheezing high-pitched whistle. Females continued to add grass to their nests, making them so tight that by two weeks after birth, the interior of the nests could not be seen without demolition.

In two litters, the young ceased to be permanently attached to the teats and were left in the nest for the first time at twenty-four and twenty-eight days. Morrison (1975) reports a litter of five being released at six weeks. Fleay (1965) reports release after five to six weeks and Aslin (1974) noted release after twenty-eight days. As Morrison (1975) points out, these differences may be due to different litter sizes.

Females now ventured out only to defaecate (four to six drops urine and two large faecal pellets) and eat. Over a three to four day interval, they may be seen only once or twice outside the nest.

First emergences from the nest by the young were noted at forty-five days. They strayed about 6 cm from the nest walked around in circles for about three minutes, and then returned. A wheezing call was uttered by females as they entered the nest and this was returned by the young. It appeared to be a 'gathering contact' call. Females' appetite increased at this time and an average of thirty mealworms each were taken nightly.

At fifty-seven days, the young took solid food (mealworms) but continued to suckle from the female who lay 'spread-eagle' above them as they lay under her in a variety of positions — on the side, back, with eyes closed and feet generally in contact with her body though not grasping. There was no 'kneading' of the teats by juveniles while sucking.

At this age a variety of interactions could be seen in the family groups. The females appeared to be very volatile in temperament toward the young. It seems as if weaning is hastened by the increased aggression of the female toward the young. When a joey approached, the female would rush to 'attack' it with a jabbing lunge directed to the head. The young would utter a threat call which would bring all the other young to the

immediate vicinity. The joey that had initially approached the female always remained motionless during the initial 'attack'. The female would calm down after the young's threat call. She would accept each baby after a small scuffle involving a rush and a mouth smell, whereupon the young, after remaining perfectly still, would rush over onto her back and cling on and climb over her. Young then jostled on the mother's back, clinging to her, jumping over her, grabbing one another and scuffling. As soon as she moved they grabbed the neck behind the ears with the incisors and lowered their bodies (resembling the male's position during copulation). All bites delivered to the young by the female at this time were open mouthed and soft.

At sixty-one days the young fed on insects after the pattern of behaviour seen in adults. When young encountered the female at this time they approached with ears back, mouth open and threat calling — but no struggles were ever seen.

At seventy-two days the young were independent of their mother; mouse pups were accepted but not cleanly killed.

They continued to sleep together in a tight bundle until about five months old, at which time the animals became more aggressive to each other and started sleeping in separate nests.

Aslin (1975) reports that reproductive maturity in females occurred at about ten months. Related information was not determined from this study.

DISCUSSION

Common Planigales have been collected from savannah woodland and grassland (Heinsohn 1970); stacked posts, neighbouring blady grass, partially flooded and generally soggy areas of peat swamp, dense forests of coarse, high grass beneath Swamp Mahogany Gums (Fleay 1965); and from debris at the base of Pandanus Palms and Melaleucas (Parker 1973). Most Common Planigales that I have collected have come from rubbish dumps in *Imperata* grasslands. Here the animals constructed small grass and leaf nests under iron and wood heaps. One adult male caught in Ingham (north Queensland) was found sleeping with a juvenile Little Melomys (*Melomys burtoni*) in a nest under corrugated iron. J. Covacevich (pers. comm.) has also observed Common Planigales nesting with Little Melomys and constructing their nests under sleepers on disused railway lines.

In the wild, Common Planigales are most probably unspecialized predators on insects (mainly), other invertebrates, and in some cases small invertebrates. Their arboreal abilities

increase their hunting range and allow access to additional types of food (e.g. small nestling birds). Their relatively poor eyesight is compensated for by a keen sense of smell and hearing as well as agility, sensitivity to stimulation of the vibrissae, and well developed snatching abilities. Their shrew-like appetite and determination to tackle prey larger than themselves has been demonstrated on many occasions. Van Deusen (1969) records a specimen of Ingram's Planigale (*Planigale ingrami*), from Karumba (north Queensland) that fed mainly on geckos, skinks, spiders and beetles but showed little interest in grasshoppers. However he notes (p. 617) '... my individual thrived on *Leggadina* (a small murid) which he killed and ate completely'. It is possible that *P. maculata* also takes a significant number of nestling and juvenile rodents in the wild.

In captivity, despite the presence of ample meat-mix food in familiar surroundings, the animals still exhibited persistent searching behaviour. If this active searching is appetitive behaviour, then perhaps the stimulus needed to bring about other action patterns and thereby stop the appetitive behaviour is not the act of eating, but the act of catching, struggling with, and killing prey. This idea may be supported by the tendency of these Planigales and other dasyurids to exhibit stereotyped boredom behaviour (where most of their activity consists of monotonously following a regular path) in dull environments and when fed on meat mixtures. The animals probably scavenge in the wild, but this activity may normally be secondary to active predation. 'It seems that dead bait does not attract them and for that reason *Planigale* is not commonly taken' (W. Hosmer in Van Deusen 1969, p. 617).

Common Planigales fall prey to many animals. Their remains have been found in owl pellet deposits (e.g. from Burleigh, S.E.Q., J13526). The high frequency with which they appear in the Queensland Museum as 'cat-kills' leaves no doubt about their vulnerability throughout their entire range of feral and pet cats. Covacevich and Archer (1975) record one collected from a Cane Toad (*Bufo marinus*) stomach. One specimen in the Queensland Museum (JM1180) is labelled as having died from the bite of a black house spider *Ixauticus robustus*. Heaviest predation probably takes place on juvenile animals just after leaving the nest (see Buchmann and Guiler 1977 for cannibalistic tendencies in *Sarcophilus harrisii*), and on mating animals which advertise their positions with persistent calling.

In young Common Planigales raised on mealworms and other insects, the methods of

handling and killing mouse pups, large grasshoppers, and other intimidating prey improved with experience. In addition food preference appeared to be learned by picking food from the mother's mouth while she ate near the young. Braithwaite (1973) states that from mid-January juvenile Brown Antechinuses (*A. stuartii*) catch food, but the young seemed to learn to feed from the female by hunting together, feeding on the female's scraps, and by stealing food. The Common Planigale's generalized diet probably necessitates the rapid development of efficient killing techniques and the ability to revise past experiences.

Wild Common Planigales are probably socially intolerant. The repertoire of calls may serve to inhibit aggression when animals come in contact.

The high degree of aggression inhibition that results from threat calls has been demonstrated in male-female interactions, mother-young interactions, and juvenile-juvenile interactions. The 'mate-finding' call initiated by females is almost certainly further evidence of this intolerance under non-breeding conditions. It is interesting that even though the animal is socially intolerant, and the female never accepts copulation without violent struggles and vocal threats, she nevertheless advertises her reproductive condition by calling and attracting potential mates. Buchmann and Guiler (1977, p. 167) note that Tasmanian Devils (*Sarcophilus harrisii*), although essentially solitary animals, are extremely vocal '... and their loud and rather eerie noises enable them to effect efficient long range communication'. They note that broadcasting tape recorded calls readily drew the elusive animals from cover and caused them to vocalize in response. Perhaps similar use may be made of recorded Planigale calls in an attempt to study them in the wild.

Male Common Planigales are generally larger than females. Braithwaite (1973) suggests that in *Antechinus stuartii* marked size difference between male and female creates less food competition between the two and thereby enhances the species' chances of survival in the same habitat. However it is also possible that it may have arisen in response to problems associated with reproduction between essentially socially intolerant animals. It is apparent that in such intolerant animals as Common Planigales, where the female is usually more vocal and aggressive than males, greater strength and weight is advantageous in males, enabling them to mate effectively and ensure that successful implantation takes place. This dimorphism could be produced by selection for the larger more persistent males

who finally overcome and mate with females. The uncooperative nature of the females ensures that genetically desirable males are selected. The aggressive behaviour exhibited by male Common Planigales during copulation as well as the extended period over which copulation takes place may further ensure conception in females.

Common Planigales marked their cages with scents recognizable at least to their own kind; cloacal rubbing was observed in both sexes and sternal rubbing took place in maturing males and oestrus females. As the rubbing by males increased, so did their aggressiveness toward the female sharing their cage. Braithwaite (1973) examines the same actions in the Brown Antechinus (*A. stuartii*) and notes that cloacal rubbing chemically marks sites of victory and possibly functions as a threat for some time. Wood (1970), studying the same animals, reports them to be strongly site attached and possessive of their territories. Johnson (1973, p. 531) points out that in many cases marking makes the habitat familiar — a sort of proximity orientation. 'In many species it is found that common marking sites are used by several individuals and marking points may be sought out and appear to elicit marking behaviour. This may be interpreted as indicating that scent marks act as sites for general exchange of information.' Johnson also suggests that marking may be involved in regulating population densities.

The concept of familiarization of the habitat seems more acceptable in the case of the Common Planigale. The animal marks its surroundings with cloacal smears, sternal rubs and faecal piles. New objects such as food trays are quickly investigated and may be marked. In such familiar surroundings more energy can then be devoted to activities such as food finding and reproduction rather than to regular assessment of the surroundings.

The reproductive cycle of *Planigale maculata* is poorly understood. Data collected from specimens in Queensland show a possible preference for summer parturition. There is no data that definitely shows the animal to be either monestrous or polyoestrous. *P. maculata sinualis* from Northern Territory is polyoestrous (see Aslin 1975). The incidence of births throughout the year in Queensland suggests that *P. maculata maculata* may follow a similar strategy.

In contrast, the Little Northern Quoll (*Dasyurus hallucatus*), and all species of *Antechinus*, breed in the spring months. The accepted explanation for this is that the increase of invertebrates during the summer provides

abundant food for the lactating females and weaning young (Braithwaite 1973, Wood 1970, and Freeland 1972). Because the grassland habitat of the Common Planigale is periodically destroyed by fire, usually in summer, large litters and extended breeding seasons would impart an adaptive advantage.

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PLATE I

- a: Adult female Common Planigale (*Planigale maculata*).
- b, c: Investigatory upright postures.
- d: Indecision-alert posture.
- e: Typical eating or grooming posture.
- f: Typical arboreal posture.
- g: Adult female eating a mouse pup.





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