= Nothomyrmecia =

Nothomyrmecia , also known as the dinosaur ant or dawn ant , is a rare genus of ants consisting of a single species , Nothomyrmecia macrops . It lives in South Australia , nesting in old @-@ growth mallee woodland and Eucalyptus woodland . The full distribution of Nothomyrmecia has never been assessed , and it is unknown how widespread it really is ; its potential range may be wider if it does favour old @-@ growth mallee woodland . Possible threats to its survival include habitat destruction and climate change . Nothomyrmecia is most active when it is cold because workers encounter fewer competitors and predators such as Camponotus and Iridomyrmex , and it also increases hunting success . Thus , the increase of temperature may prevent them from foraging and very few areas would be suitable for the ant to live in . As a result , the IUCN lists the ant as Critically Endangered .

A medium @-@ sized ant , Nothomyrmecia measures 9 @.@ 7 ? 11 mm (0 @.@ 38 ? 0 @.@ 43 in) . Workers are monomorphic , showing little morphological differentiation among one another . Mature colonies are very small , with only 50 to 100 individuals in each nest . Workers are strictly nocturnal (active mainly at night) and are solitary foragers , collecting arthropod prey and sweet substances such as honeydew from scale insects and other Hemiptera . They rely on their vision to navigate and there is no evidence to suggest that the species use chemicals to communicate when foraging , but they do use chemical alarm signals . A queen ant will mate with one or more males and , during colony foundation , she will hunt for food until the brood have fully developed . Queens are univoltine (i.e. they produce just one generation of ants each year) . Two queens may establish a colony together , but only one will remain once the first generation of workers has been reared .

Nothomyrmecia was first described by Australian entomologist John S. Clark in 1934 from two specimens of worker ants . These were reportedly collected in 1931 near the Russell Range , inland from Israelite Bay in Western Australia . After its initial discovery , the ant was not seen again for four decades until a group of entomologists rediscovered it in 1977 , 1 @,@ 300 km (810 mi) away from the original reported site . Dubbed as the ' Holy Grail ' of myrmecology , the ant was subject to great scientific interest after its rediscovery , attracting scientists from around the world . In Poochera (the rediscovery site) , pictures of the ant are stenciled on the streets , and it is perhaps the only town in the world that thrives off ant @-@ based tourism . Some entomologists have suggested a relationship to the Baltic Eocene fossil ant genus Prionomyrmex based on morphological similarities , but this interpretation is not widely accepted by the entomological community . Owing to its body structure , Nothomyrmecia is regarded to be the most primitive ant alive and a ' living fossil ' , stimulating studies on its morphology , behaviour , ecology , and chromosomes .

= = Description = =

Nothomyrmecia is a medium @-@ sized ant , measuring 9 @.@ 7 ? 11 mm (0 @.@ 38 ? 0 @.@ 43 in) in length . Workers are monomorphic , meaning that there is little morphological differentiation among one another . The mandibles , clypeus (one of the sclerites that make up the " face " of an arthropod or insect) , antennae and legs are pale yellow . The hairs on the body are yellow , erect and long and abundant , but on the antennae and legs they are shorter and suberect (standing almost in an erect position) . Though it shows similar characteristics to Myrmecia , Nothomyrmecia somewhat resembles Oecophylla , commonly known as weaver ants . Workers are strictly nocturnal (active mainly at night) but navigate by vision , relying on large compound eyes . The mandibles are shorter than the head . They have 10 to 12 teeth and are less specialised than those of Myrmecia and Prionomyrmex , being elongate and triangular . The head is longer than it is wide and broader towards the back . The sides of the head are convex around the eyes . The long antennal scapes (the base of the antenna) extend beyond the occipital border , and the second segment of the funiculus (a series of segments between the base and club) is slightly longer than the first , third and fourth segment . The node , pronotum , epinotum and thorax are longer than broad , and the mesonotum is just as long as it is wide . The first segment of the gaster (the

bulbous posterior portion of the metasoma) is broader than long by a third and broader at the back than the front with strongly convex sides .

A long and retractable stinger is present at the rear of the abdomen . It has been described as " prominent and effective " and is capable of inflicting a painful sting to humans . A ' sting bulb gland ' is also present in Nothomyrmecia ; this is a small exocrine gland of unknown function , first discovered and named in 1990 . It is situated in the basal part of the insect 's sting , and is located between the two ducts of the venom gland and the Dufour 's gland . Despite its many primitive features , the sting apparatus of Nothomyrmecia is considered less primitive than those found in other ants such as Amblyopone pallipes . It is the only known species of ant that contains both a sting and a ' waist ' (i.e. it has no postpetiole between the first and second gastral segments) .

Queens look similar to workers , but several morphological features distinguish the two castes from each other . Although their body structure is similar to that of workers , the queens are usually larger . Ocelli are highly developed , but the eyes on the queen are not enlarged . The structure of the pterothorax (the wing @-@ bearing area of the thorax) is consistent with other reproductive ants , although it does not occupy as much of its mesosomal bulk . The wings of the queens are reduced to the point that they are not functional (they are brachypterous) . Their wings are noticeably rudimentary and stubby , barely overlapping the first gastral segment . Males resemble those of Myrmecia , but Nothomyrmecia males bear a single waist node . The wings on the male ant are not stubby like a queen 's ; rather they are long and fully developed , exhibiting a primitive venational complement , They have a jugal anal lobe (a portion of the hindwing) , a feature found in many primitive ants , and basal hamuli (hook @-@ like projections that link the forewings and hindwings) . Most male specimens collected have two tibial spurs (spines located on the distal end of the tibia) ; the first spur is a long calcar while the second spur is short and thick . Adults have a stridulatory organ on the ventral side of the abdomen ? unlike all other hymenopterans in which such organs are located dorsally .

In all castes , these ants have six maxillary palps (palps that serve as organs of touch and taste in feeding) and four labial palps (sensory structures on the labium) , a highly primitive feature . The females have a 12 @-@ segmented antenna , whereas males have 13 segments . Other features include paired calcariae found on both the hind and middle tibiae , and the claws have a median tooth . The unspecialised nature of the cuticle (outer exoskeleton of the body) is similar to Pseudomyrmex , a member of the subfamily Pseudomyrmecinae . Many of the features known in Nothomyrmecia are found in Ponerinae and Pseudomyrmecinae .

The eggs of Nothomyrmecia are similar to those of Myrmecia , being subspherical and non @-@ adhesive . The larvae bear a primitive body structure with no specialised tubercles , sharing similar characteristics with the subfamily Ponerinae , but the sensilla are more abundant on the mouthparts . The larvae are characterised into three stages : very young , young , and mature , measuring 2 @.@ 8 mm (0 @.@ 1 in) , 6 @.@ 3 mm (0 @.@ 2 in) and 11 mm (0 @.@ 4 in) , respectively . The cocoons have thin walls and produce meconium (a metabolic waste product expelled through the anal opening after an insect emerges from its pupal stage) . The cuticular hydrocarbons have internally branched alkenes , a feature rarely found in ants and most insects .

In general , the body structure of all Nothomyrmecia castes demonstrates the primitive nature of the species . Notable derived features include vestigal ocelli on workers , brachypterous queens , and the mesoscutal structure on males . The morphology of the abdomen , mandibles , gonoforceps (a sclerite , serving as the base of the ovipositors sheath) and basal hamuli show it is more primitive than Myrmecia . The structure of the abdominal region can separate it from other Myrmeciinae relatives (the fourth abdominal segment of Myrmecia is tubulate , whereas Nothomyrmecia has a non @-@ tubulated abdominal segment) . The appearance of the fourth abdominal segment is consistent with almost all aculeate insects , and possibly Sphecomyrma .

The feature of non @-@ functional , vestigial wings may have evolved in this species relatively recently , as wings might otherwise have long @-@ since disappeared completely had they no function for dispersal . Wing @-@ reduction could somehow relate to population structure or some other specialised ecological pressure . Equally , wing @-@ reduction might be a feature that only forms in drought @-@ stressed colonies , as has been observed in several Monomorium ant

species found throughout semi @-@ arid regions of Australia . As yet , scientists do not fully understand how the feature of non @-@ functional , vestigial wings arose in Nothomyrmecia macrops .

= = Taxonomy = =

= = = Discovery = = =

The first collection of Nothomyrmecia was made in December 1931 by amateur entomologist , Amy Crocker , whose colleagues had collected a range of insect samples for her during a field excursion , including specimens of two worker ants , reportedly near the Russell Range , inland from Israelite Bay in Western Australia . Crocker then passed the ants to Australian entomologist John S. Clark . Recognised shortly afterwards as a new species , these specimens became the syntypes . Entomologist Robert W. Taylor subsequently expressed doubt about the accuracy of recording of the original discovery site , stating the specimens were probably collected from the western end of the Great Australian Bight , south from Balladonia . The discovery of Nothomyrmecia and the appearance of its unique body structure led scientists in 1951 to initiate a series of searches to find the ant in Western Australia . Over three decades , teams of Australian and American collectors failed to re @-@ find it ; entomologists such as E. O. Wilson and William Brown , Jr . , made attempts to search for it , but neither was successful . Then , in 1977 , Taylor and his party of entomologists from Canberra serendipitously discovered a solitary worker ant at Poochera , southeast of Ceduna , some 1 @,@ 300 km (810 mi) from the reported site of the 1931 discovery . In 2012 , a report discussing the possible presence of Nothomyrmecia in Western Australia did not confirm any sighting of the ant between Balladonia and the Western Australian coastal regions . After 46 years of searching for it , entomologists have dubbed the ant the ' Holy Grail ' of myrmecology .

= = = Naming = = =

In 1934 entomologist John S. Clark published a formal description of Nothomyrmecia macrops as a new species and within a completely new genus and tribe (Nothomyrmecii) of the Ponerinae . He did so because the two specimens (which then became the syntypes) bore no resemblance to any ant species he knew of , although they did share similar morphological characteristics with the extinct genus Prionomyrmex . Clark notes that the head and mandibles of Nothomyrmecia and Prionomyrmex are somewhat similar , but the two can be distinguished by the appearance of the node (a segment between the mesosoma and gaster) . In 1951 , Clark proposed the new ant subfamily Nothomyrmeciinae for his Nothomyrmecia , based on morphological differences with other ponerine ants . This proposal was rejected by American entomologist William Brown Jr . , who would place it into the subfamily Myrmeciinae with Myrmecia and Prionomyrmex , under the tribe Nothomyrmeciini . Its distant relationship with extant ants was confirmed after its rediscovery , and its placement within the Formicidae was accepted by most scientists until the late 1980s . The single waist node led scientists to believe that Nothomyrmecia should be separate from Myrmecia and retained Clark 's original proposal . This proposal would place the ant into its own subfamily , despite many familiar morphological characteristics between the two genera . This separation from Myrmecia was retained until 2000 .

In 2000 , entomologist Cesare Baroni Urbani described a new Baltic fossil Prionomyrmex species (P. janzeni) . After examining specimens of Nothomyrmecia , Baroni Urbani stated that his new species and N. macrops were so morphologically similar that they belonged to the same genus . He proposed that the name Prionomyrmex should replace the name Nothomyrmecia (which would then be just a synonym) , and also that the subfamily Nothomyrmeciinae should be called Prionomyrmeciinae .

In 2003 , Russian palaeoentomologists G. M. Dlussky and E. B. Perfilieva separated

Nothomyrmecia from Prionomyrmex on the basis of the fusion of an abdominal segment . In the same year , American entomologists P. S. Ward and S. G. Brady reached the same conclusion as Dlussky and Perfilieva and provided strong support for the monophyly of Prionomyrmex . Ward and Brady also transferred both taxa as distinct genera in the older subfamily Myrmeciinae under the tribe Prionomyrmecini . In 2005 and 2008 , Baroni Urbani suggested further evidence in favour of his former interpretation as opposed to Ward and Brady 's . This view is not supported in subsequent relevant papers , which continue to use the classification of Ward and Brady , rejecting that of Baroni Urbani .

The ant is commonly known as the dinosaur ant , dawn ant , or living fossil ant because of its primitive body structure . The generic name Nothomyrmecia means " false bulldog ant " . Its specific epithet , macrops (" big eyes ") , is derived from the Greek words makros , meaning " long " , or " large " , and ops , meaning " eyes " .

= = = Genetics and phylogeny = = =

Studies show that all hymenopteran insects that have a diploid (2n) chromosome count above 52 are themselves all ants ; Nothomyrmecia and another Ponerinae ant , Platythyrea tricuspidata , share the highest number of chromosomes within all the Hymenoptera , having a diploid chromosome number of 92 ? 94 .

Genetic evidence suggests that the age of the most recent common ancestor for Nothomyrmecia and Myrmecia is approximately 74 million years old , giving a likely origin in the Cretaceous . There are two hypotheses of the internal phylogeny of Nothomyrmecia : subfamily Formicinae is more closely related to Nothomyrmecia than it is to Myrmecia , evolving from Nothomyrmecia @-@ like ancestors . Alternatively , Nothomyrmecia and Aneuretinae may have shared a common ancestor ; the two most likely separated from each other , and the first formicines evolved from the Aneuretinae instead . Currently , scientists agree that Nothomyrmecia most likely evolved from ancestors to the Ponerinae . Nothomyrmecia and other primitive ant genera such as Amblyopone and Myrmecia exhibit behaviour similar to a clade of soil @-@ dwelling families of vespoid wasps . The following cladogram generated by Canadian entomologist S. B. Archibald and his colleagues shows the possible phylogenetic position of Nothomyrmecia among some ants of the subfamily Myrmeciinae . They suggest that Nothomyrmecia may be closely related to extinct Myrmeciinae ants such as Avitomyrmex , Macabeemyrma , Prionomyrmex , and Ypresiomyrma .

= = Distribution and habitat = =

Nothomyrmecia is present in the cool regions of South Australia within mallee woodland and especially old @-@ growth areas populated with various Eucalyptus species , including Eucalyptus brachycalyx , E. gracilis and E. oleosa . It is possible that it also occurs in Western Australia , from where it was first collected . The full distribution of Nothomyrmecia has never been assessed , and it is unknown how widespread it really is . If it does favour old @-@ growth mallee woodland , it could have the potential for a wider range than is currently known from surveys and museum specimens . In 1998 , Nothomyrmecia colonies were located in 18 areas along the Eyre Peninsula by a team of entomologists , a stretch of 400 km (250 mi) .

Nests are found in degraded limestone soil with Callitris trees present . Colony construction only occurs when the soil is moist . Nest entrance holes are difficult to detect as they are only 4 ? 6 mm (0 @.@ 16 ? 0 @.@ 24 in) in width , and are located under shallow leaf litter with no mounds or soil deposits present , although guards are regularly seen . A single gallery , 4 ? 5 mm (0 @.@ 16 ? 0 @.@ 20 in) in diameter , forms inside a Nothomyrmecia colony . This gallery descends steeply into the ground towards a somewhat elliptical and horizontal chamber that is 3 ? 5 cm (1 @.@ 2 ? 2 @.@ 0 in) in diameter and 5 ? 10 mm (0 @.@ 20 ? 0 @.@ 39 in) in height . This chamber is typically 18 to 43 cm (7 @.@ 1 to 16 @.@ 9 in) below the soil 's surface .

= = Behaviour and ecology = =

= = = Foraging , diet and predators = = =

Workers are nectarivores and can be found foraging on top of Eucalyptus trees , where they search for food and prey for the larvae . However , workers are known to drink hemolymph from the insects they capture , and a queen in a captive colony was observed consuming a fly . Captured prey items are given to larvae , which are carnivorous . The workers search for prey in piles of leaves , killing small arthropods including Drosophila flies , microlepidopterans and spiderlings . Prey items are usually less than 4 mm (0 @.@ 2 in) in size , and workers grab them using their mandibles and forelegs , then kill them with their sting . Workers also feed on sweet substances such as honeydew secreted by scale insects and other Hemiptera ; one worker alone may feed on these sources for 30 minutes . Pupae may be given to the larvae if a colony has a shortage of food . Workers are able to lay unfertilised eggs specifically to feed the larvae ; these are known as trophic eggs . Sometimes the adults , including the queen and other sexually active ants , consume these eggs . Workers transfer food to other nestmates , including winged adults and larvae ; the anal droplets are exuded by the larvae , which are taken up by the workers .

Age caste polyethism does not occur in Nothomyrmecia , where the younger workers act as nurses and tend to the brood and the older workers go out and forage . The only ant known other than Nothomyrmecia which does not exhibit age caste polyethism is Stigmatomma pallipes . Workers are strictly nocturnal , and only emerge from their nests on cold nights . They are most active at temperatures of 5 ? 10 ° C (41 ? 50 ° F) , and are much more difficult to locate on warmer nights . Workers are possibly most active when it is cold because at these times they encounter fewer and less aggressive competitors , including other more dominant diurnal ant species that are sometimes found foraging during warm nights . Cold temperatures may also hamper the escape of prey items , so increasing the ants ' hunting success . Unless a forager has captured prey , workers stay on trees for the remainder of the night until dawn , possibly relying on sunlight to navigate back to their nest . There is no evidence that they use chemical trails when foraging ; instead , workers rely on visual cues to navigate around . However , chemical markers may play an important role in recognising nest entrances . The ants are solitary foragers . Waste material , such as dead nestmates , cocoon shells , and food remnants , are disposed of far away from the nest .

Workers from different Nothomyrmecia colonies are not antagonistic towards one another , so they can forage together on a single tree , although they do attack if an outsider tries to enter an underground colony . Ants such as Camponotus and Iridomyrmex may pose a threat to foragers or to a colony if they try to enter ; foraging workers that encounter Iridomyrmex ants are vigorously attacked and killed . Nothomyrmecia workers counter this by secreting alarm pheromones from the mandibular gland and Dufour 's gland . Foraging workers also engage in alternative methods to protect themselves from predators . Adopting a posture by opening the jaws in a threatening stance or deliberately falling onto the ground and remaining motionless until the threat subsides are two known methods . With that said , Nothomyrmecia is a timid and shy species that retreats if exposed .

= = = Life cycle and reproduction = = =

Nuptial flight (meaning that virgin queens and males emerge to mate) does not occur in Nothomyrmecia . Instead , they engage in long @-@ range dispersal (they walk away from the colony for some distance and mate) which presumably begins by late summer or autumn , with the winged adults emerging around March and April , but sometimes a colony may overwinter (a process by which an organism waits out the winter season) . These winged adults , born around January , are usually quite young when they begin to mate . Queens are seen around vegetation trying to flutter their vestigial wings ? a behaviour seen in some brachypterous Myrmecia queens . Due to the queen 's brachypterous wings , it is likely that the winged adults mate near their parent nest and release sex pheromones , or instead climb on vegetation far away from their nests and

attract fully winged males . Nothomyrmecia is a polyandrous ant , in which queens mate with one or more males . In one study of 32 colonies , it was found that queens mated with an average of 1 @.@ 37 males . After mating , new colonies can be founded by one or more queens , though a colony with two queens reduces to a single queen when the nest is mature , forming colonies that are termed monogynous . The queens will compete for dominance , and the subordinate queen is later expelled by workers who drag her outside the nest . An existing nest with no queen may adopt a foraging queen looking for an area to begin her colony , as well as workers . Queens are semi @-@ claustral , meaning that during the initial establishment of the new colony the queen will forage among the worker ants so that she can ensure sufficient food to raise her brood . Sometimes a queen will leave her nest at night with the sole purpose of finding food or water for herself .

Eggs are not seen in nests from April to September . They are laid by late December and develop into adults by mid @-@ February , although pupation does not occur until March . However , Nothomyrmecia is univoltine , meaning that the queen produces a single generation of eggs per season , and it sometimes may take as many as 12 months for an egg to develop into an adult . Adults are defined as either juveniles or post @-@ juveniles : juveniles are too young (perhaps several months old) to have experienced overwintering whereas post @-@ juveniles have . The pupae generally overwinter and begin to hatch by the time a new generation of eggs is laid . Workers are capable of laying reproductive eggs , although it is not known if these develop into males , females or both . This uncertainty results from the suggestion that , because some colonies have been shown to have high levels of genetic diversity , worker ants could be inseminated by males and act as supplementary reproductives . Eggs are scattered among the nest , whereas the larvae and pupae are set apart from each other in groups . The larvae are capable of crawling around the nest . When the larvae are ready to spin their cocoons , they swell up and are later buried by workers in the ground to allow cocoon formation . Small non @-@ aggressive workers that act as nurses provide assistance for newborns to hatch from their cocoons . At maturity , a nest may only contain 50 to 100 adults . In some nests , colony founding can occur within a colony itself : when a queen dies , the colony may be taken over by one of her daughters , or it may adopt a newly mated queen , restricting reproduction among workers ; this method of founding extends the lifespan of the colony almost indefinitely .

= = Relationship with humans = =

= = = Conservation = = =

Before its rediscovery in 1977 , entomologists feared that Nothomyrmecia had already become extinct . The ant was listed as a protected species under the Western Australian Wildlife Conservation Act 1950 . In 1996 , the International Union for Conservation of Nature listed Nothomyrmecia as Critically Endangered , stating that only a few small colonies were known . However , the Threatened Species Scientific Committee states that the species is ineligible for listing under the Environment Protection and Biodiversity Conservation Act 1999 . This is because there is insufficient evidence to demonstrate that populations are declining . Colonies are also naturally depauperate (lacking in numbers of ants) , and their distribution is potentially quite extensive across southern Australia , due to the ants ' preference for old @-@ growth mallee woodland . With 18 sites known for this species , and the potential for many more being discovered , there seems little immediate possibility of extinction . With this said , it is unknown how widespread it actually is , and scientists are not yet clear what , if any , threats are impacting on it .

Although threats are not known for certain , suspected anthropogenic threats that can significantly impact Nothomyrmecia include habitat destruction and fragmentation by railway lines , roads and wheat fields . In the town of Ceduna , west of Poochera , local populations of the ant were almost eliminated after the area was bulldozed and burned during the installation of an underground telephone line , although nearby sites had larger populations than those found in the destroyed site . Colonies may not survive tree @-@ clearing , as they depend on overhead canopies to navigate .

Bushfires are another major threat to the survival of Nothomyrmecia , potentially destroying valuable food sources , including the trees they forage on , and reducing the population of a colony . Although these ants may have recovered from previous bushfires , larger , more frequent fires may devastate the population . However , Nothomyrmecia ants can be safe from fires if they remain inside their nests . Climate change could be a threat to their survival , as they depend on cold temperatures to forage and collect food . An increase in the temperature will prevent workers from foraging , and very few areas would be suitable for the species to live in . The cold winds blowing off the Southern Ocean allow Nothomyrmecia to benefit from the cool temperatures they need for night @-@ time foraging , so an increase in sea temperature could also potentially threaten it .

Conservationists suggest that conducting surveys , maintaining known populations through habitat protection and fighting climate change may ensure the survival of Nothomyrmecia . They also advocate protection of remaining mallee habitat from degradation , and for management actions to improve tree and understorey structure . Because most known populations are found outside protected areas in vegetation alongside roads , a species management plan is required to identify other key actions , including making local councils aware of the presence , conservation status and habitat requirement of Nothomyrmecia . This could result in future land use and management being decided more appropriately at the local level . Not all colonies are found in unprotected areas ; some have been discovered in the Lake Gilles Conservation Park and the Chadinga Conservation Reserve . More research is needed to know the true extent of the ant 's geographical distribution .

= = = Significance = = =

Nothomyrmecia macrops is widely regarded as the most primitive living ant and , as such , has aroused considerable interest among the entomological community . Following its rediscovery it was the subject of a prolonged and rigorous series of studies involving Australian , American and European ant specialists and it soon became one of the most studied ant species on the planet . Nothomyrmecia can be cultured with ease , and could potentially prove a useful subject for research into learning in insects as well as the physiology of nocturnal vision . Since its chance discovery at Poochera , the town has became of international interest to myrmecologists , and it is possibly the only town in the world with ant @-@ based tourism . Promoting it as a tourist attraction , Nothomyrmecia has been adopted as the emblem of the Poochera community . Pictures of the ant have been stencilled onto the pavements , and a large sculpture of Nothomyrmecia has been erected in the town .

= = = Cited literature = = =

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