Cooperative Extension

Arizona Termites of Economic Importance

AZ 1369
June 2005

The University of Arizona®
College of Agriculture and Life Sciences

Arizona Termites of Economic Importance

PAUL B. BAKER
Specialist, Entomology

RUBEN J. MARCHOSKY, JR.
Research Specialist, Senior

Photographs and Illustrations by
ALEX J. YELICH

This information has been reviewed by university faculty.
cals.arizona.edu/pubs/insects/az1369.pdf

AZ1369

June 2005

Cooperative Extension
College of Agriculture and Life Sciences
The University of Arizona
Tucson, Arizona 85721

Termites are cryptic social insects that play an important role in many ecosystems. They decompose wood and other cellulose-based materials, physically redistribute soil materials modifying soil profiles, and recycle organic matter and nutrients. Termites comprise the order ***Isoptera*** (iso-ptera fi "equal-winged"), so named because the reproductive adult has two pairs of equal length wings. Currently, there are more than 2,600 identified termite species in 281 genera worldwide [13]. However, only 183 species are known to damage buildings [5,37,38]. Most of the world's species are found in the tropical regions. About 45 species occur in the continental United States with nearly 30 causing damage to wood and wood products [35]. Of the eighteen (18) species of termites that are commonly found in Arizona, several species are economically important.

Termites can be placed into 3 general categories based on their habitat: ***dampwood, drywood*** and ***subterranean.*** In Arizona, dampwoods do not present wide spread pest problems, but can be problematic under certain conditions. In certain locations throughout the state, drywood termites are significant and costly pests. Subterranean termites are considered major urban pests throughout the state. The purpose of this publication is to introduce the reader, in particular homeowners and pest management professionals (PMP's), to termites in general, and more specifically the pest species that inhabit Arizona.

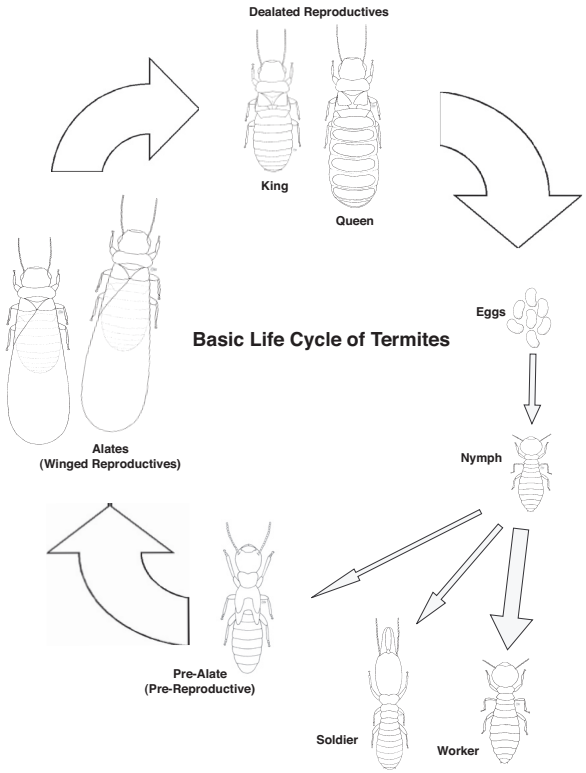

Fig. 1.The basic lifecycle of termites.

Termite Biology

Termites live in true social groups with a division of labor required of the different castes of individuals: ***reproductive adults, soldiers,*** and ***workers***. Termites have a complex lifecycle with the development of individuals that look and behave differently from other members of the group. Figure 1 demonstrates a typical lifecycle of termites. There are three general developmental stages: egg, immature, and adult. The primary role of ***winged adults*** is dispersal and reproduction. The actual work of the colony and expansion of the colony's foraging territory is performed by the caste of ***workers,*** while ***soldiers*** defend the colony.

Winged adults (*alates or swarmers*) represent a primary caste of individuals within the termite colony. Winged adults can vary in color from light tan to reddish brown to nearly black. The size of these adults with wings attached ranges in length from one-half to greater than an inch. Their eyes are fully developed, mandibles (jaws) are typically visible, and they have membranous wings. They possess paired antennae that are often bead-like or *moniliform*. Winged adults or alates disperse from their colony of origin in a series of flights or swarms at precise times of the year. The timing of the flights varies among species, and within species based on locality. Adults may be attracted to lights, where pairing begins. As swarmers land on the ground, their wings are shed and they start searching for a suitable place to initiate a colony. The males are attracted to the females by a scent or pheromone. Together they dig into the wood or moist soil depending on the species, and form a chamber. Mating occurs within the nuptial chamber, and the queen once fertilized initiates the new colony as she begins to lay eggs. The eventual size and rate of growth of the colony differs between dampwoods, drywoods, and subterranean termites, and among species of each habitat type.

Of the millions of alates that swarm every year, only a small percent, usually less than 1%, survive to produce a colony. Adults swarm from the original colony only when specific environmental conditions are met. Factors that control the timing of swarms are temperature, light, humidity, and barometric pressure. The environmental cues that trigger dispersal vary from species to species. For example, subterranean termites in Arizona tend to swarm in mass on the night after a substantial summer rain. On the other hand, drywood termites may fly during daylight hours on hot sunny days regardless of the rainfall.

At the time of the swarm, a winged female's abdominal sections are close to one another and her inter-segmental membranes are not noticeable. After the dispersal flight, the female become reproductively functional, and mates with the male partner. Morphological changes occur and the female's abdomen gradually expands with the inter-segmental membranes becoming increasingly noticeable. After a number of years and repeated mating activity, the queen contains a large number of developing eggs, her abdomen is greatly enlarged and the segments are widely separated by inter-segmental membranes. These features help identify the termite queen (Figure 2).

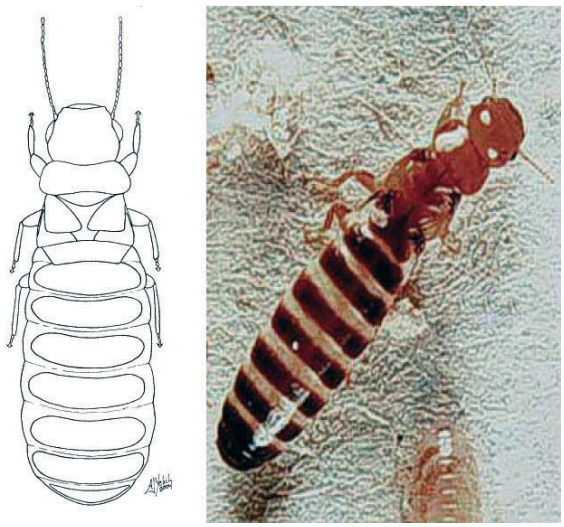

Fig. 2. *Gnathamitermes* sp. termite queen.

The king and queen are the primary reproductive adults in the initial colony. As the colony becomes larger and more established, ***neotenic reproductives*** may develop and play a major role in egg production. These neotenic reproductives are a group of immature individuals that develop functional reproductive organs without ever leaving the nest. They are produced within the nest when one or both of the primary functional reproductives have died or have become less fecund or infertile. Production of supplementary reproductives may occur when a section of the colony becomes isolated from the main group. ***Budding*** or breaking from the main group can be caused by breakage or collapse of foraging tubes during flooding of subterranean galleries. Neotenic reproductives generally have lower individual egg laying capacity than the primary queen, but there can be several hundred present in a subterranean colony [33]. When a colony produces many supplementary reproductives, it acquires the capacity for rapid population growth and expansion.

Workers are the primary foragers in a termite colony. They are the form that you often encounter when you actually see termites. These soft-bodied creamy-white insects comprise the largest caste within a termite colony. Workers are the termites that actually damage wood or cellulose products. Despite their looks, they have powerful mouthparts adapted for chewing wood. Workers perform a variety of tasks including: caring for the eggs and young larvae; constructing the colony foraging network; rebuilding tunnels and galleries when they are damaged; foraging for and providing food to alates, soldiers, and one another; assisting other termites when they molt; and grooming and cleaning nestmates. They can help soldiers to defend the colony if an attack occurs from ants or foreign termites.

In "lower termite species", the worker caste is made up of immature individuals that perform the work within the colony. Lower termites are more primitive termites that rely on protozoa (single-celled animals) contained in their gut to help digest cellulose to simple sugars. These immature termites are not reproductively functional, wingless, and in most species, blind. Workers of the termite families, Termopsidae (dampwoods) and Rhinotermitidae (subterraneans), are called "pseudoworkers" or "pseudergates". Workers of the family Kalotermitidae (drywoods) are generally referred to as "nymphs". Drywood immature termites can progress through developmental stages in a normal manner, larva to pseudergate to nymph, or undergo regressive moults losing the characteristic of the older stage [30]. On the other hand, Rhinotermitidae pseudergates remain immature throughout their life, but have the ability to develop into soldiers or winged adults. Thus, lower termite colonies are plastic as their immature termites have the ability to develop into exactly what the colony needs to survive: soldiers for defense, winged adults for colony dispersal, *neotenic* reproductives for supplemental egg production, or simply tunnel builders.

In "higher termites" (Termitidae), the developmental pathways that give rise to reproductive and non-reproductive lines differentiate early in development, and thus colonies are not very plastic [26]. Newly emerged larvae all appear the same, but after the first molt developmental trajectories can be identified. The larvae of workers show no wing development and gonads are reduced, while the nymphs of alates show definite development of sexual organs and visible small wing pads. Nonetheless, there are other mechanisms that provide for the social flexibility needed to meet the changing needs of a colony. Both sex-determined and age-related differences in the tasks performed by workers for the colony (***polyethism***) have been demon-

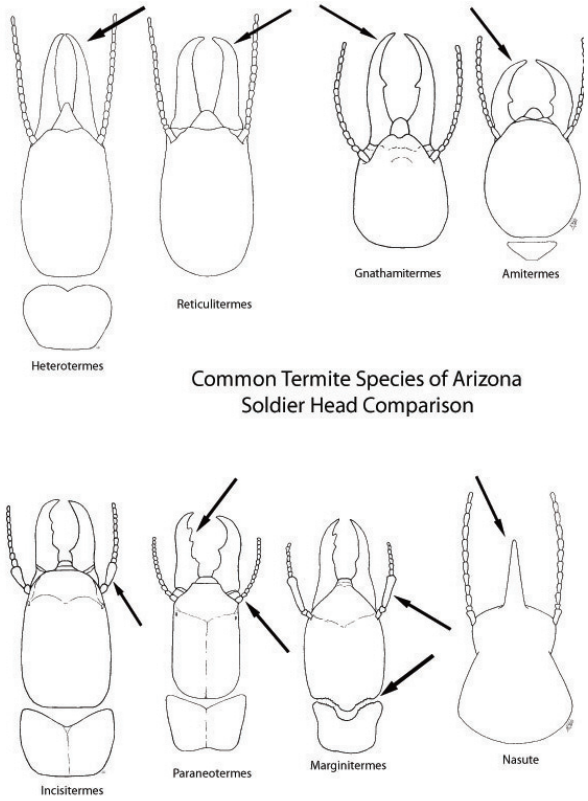

Fig. 3. Soldier head capsules of common Arizona termites.

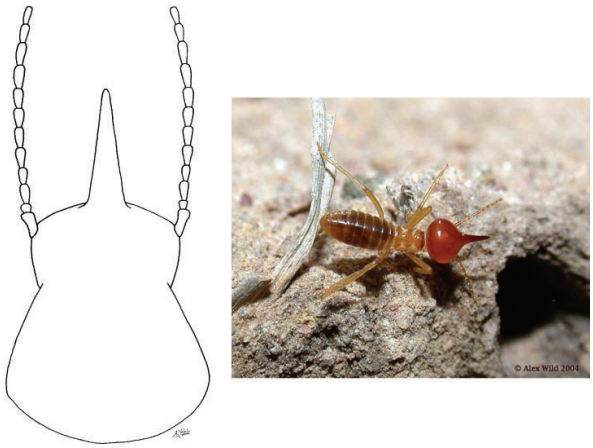

Fig. 4. A nasute soldier, *Tenuostritermes* sp. (photo: Alex Wild, 2004)

strated in higher termites [1,9, 26,30]. For example, male workers may forage for food, while female workers remain to attend the queen. These sex-related differences in behavior occur in the genera *Odontotermes* and *Macrotermes* [1,9,30]. Differences in behavior and physical size mediated by sex may even result in the formation of sub-castes with major and minor workers. In *Macrotermes michaelseni,* the major workers are male, and the smaller minor workers are female [26]. The performance of different functions by workers for the colony can also be an age-related phenomenon. A clear change from the performance of tasks within the nest to tasks outside the nest with increasing age has been observed in two different *Macrotermes* species [1,9].

Soldiers, like alates, represent a terminal individual and, therefore, a distinct caste. Once developed, a soldier is no longer capable of molting again to become larger soldier. Soldiers function simply to defend the colony against other termites and ants by using there greatly enlarged jaws or mandibles. The soldier's anatomy is simplified in comparison to an adult reproductive or a worker. Organs related to dispersal or to reproduction are reduced in soldiers. For example, a worker's gut develops for maximum utilization and digestion of cellulose and other nutrients, while the gut in a soldier is primitive or significantly reduced in form. Whether male or female, soldiers are sterile. Soldiers do not dig or construct tunnels. Soldiers do not care for one another, nor can they even feed themselves. They are dependent on workers to provide them food.

Soldiers utilize two kinds of weapons for attacking intruders: mandibles and defensive secretions. Hypertrophied mandibles (jaws) vary in size, shape and mode of utilization among species (Figure 3). Soldiers use their jaws to slash, puncture and even crush their opponents [33]. Some species have long snapping mandibles that cannot open, but flick across one another striking lateral blows to an enemy [27]. Mandibles may be symmetric with each jaw striking to the opposite side or asymmetric. When the jaws are asymmetric, the shorter right mandible allows the left jaw to strike to the right with greater power. In many species defensive chemicals are produced in enlarged salivary and labial glands and administered with snapping bites [27]. Chemical defense is not observed in the more primitive termite families, such as drywood termites (Kalotermitidae). In higher termites, there has been differentiation of the frontal gland. This gland is enlarged and maximally developed in soldiers, and produces a huge variety of defensive compounds. These soldiers generally deliver a defensive secretion via a frontal pore. The exact mode of delivery and the exact composition of the defensive chemical vary among species. Some species will even deliver the chemical secretion by ***autothysis,*** self-rupture of the body wall, which results in the death of the soldier and its enemy [4,27]. Alternatively, nasute soldiers can squirt their secretion from a distance and avoid direct contact with enemy soldiers or ants (Figure 4).

Termite Ecology

Termites are a highly successful group of true social animals as evidenced by their worldwide distribution, and evolutionary persistence. In the southwest (as in other regions), they serve an important ecological role in the decomposition of cellulose materials. Cellulose is an abundant substance that also happens to be both resistant to chemical and mechanical decomposition, and nutritionally poor. The molecule is a long chain polysaccharide made up of a large number of tightly bonded sugars. It cannot be chemically broken down without the presence of the enzyme, *cellulase*. Primitive termites do not produce sufficient cellulase for survival, but contain protozoans in their gut that aid in cellulose breakdown. These termites grind up cellulose with their mandibles and chew and swallow it. Once in their gut, flagellated protozoa break down cellulose into its constituent sugars that both the termite and protozoa use as nutrients. This interaction is an ***obligate mutualism*** for both termite and protozoa. Lower termite species, from which protozoa have been experimentally removed, continue to feed, but quickly starve to death. Higher termites (Termitidae) do produce sufficient cellulase in their mid-gut to digest adequate nutrition from cellulose, but still form mutualisms with both bacterial and fungal biota. Here symbiosis may aid termites not only with an improved supply of nitrogen, but provide a source of degraded *lignin*, detoxify *allelochemicals*, and optimize electron transfer during gut fermentations [2].

Under natural conditions in the Sonoran desert, termites feed on dead plant material, including roots, leaf litter, grass, and even cactus skeletons [11]. They may also feed on dung and humus [11]. Due to the aridity that limits the abundance of wood decaying fungi in the desert, the feeding activity by termites is critical to the recycling of nutrients in this ecosystem. Unfortunately for us, termites often infest human-made structures and damage lumber, sheetrock, wallpaper, wood panels and furniture. Despite their small appearance and soft bodies, they have hard saw-toothed jaws that work like shears to bite off extremely small pieces of wood, one fragment at a time. These termites spend their entire life in soil or within their food source. Once removed from their protected environment and favorable humidity, they die. Regardless of what people say, they do not consume concrete, stucco, fiberglass insulation or other non-organic materials. However, they may damage these materials and use them to line and support their shelter tubes.

In Arizona, we have all 3 categories of termites based on habitat: *dampwood, drywood* and *subterranean*. The termites in each category have morphological features and behavior that make them distinct. Dampwood and drywood termites can be pests under certain situations. The dampwood termite, *Paraneotermes simplicicornis* (Banks), requires more wood moisture than is provided by ambient humidity. Under natural conditions, they are restricted to moist wood in contact with the damp soil [23]. However, these insects can be pests of lumber exposed to excess water from rain or wet soil. Drywood termites make up a diverse, but primitive, family of termites that includes about 500 species [14]. Only about 10% of these species are pests of sound dry structural lumber or wood furniture [38]. Two drywood termite species, *Incisitermes minor* (Hagen) and *Marginitermes hubbardi* (Banks), are significant pests in Arizona. They require no contact with the soil and live entirely within their food source. The third category, subterranean termites, is the most widespread and destructive group within the United States and worldwide [6,33]. They derive their name *subterranean termites* because of their association with soil. They construct underground tunnels to move about in search of food. If a food source happens to be above ground, some construct ***shelter tubes*** onto the food source. These mud tubes are used to control environmental conditions and provide protection. Those food sources often also happen to be our homes. Subterranean termites can be pervasive pests, and account for at least 80% of losses to wooden structures [33, 37]. In Arizona, four subterranean termites species have the capacity to become pests: 1) *Reticulitermes tibialis* (Banks); 2) *Heterotermes aureus* (Snyder); 3) *Amitermes wheeleri* (Desenex), and 4) *Gnathamitermes perplexus* (Banks). *Heterotermes aureus* is considered our number one economic urban pest. Table 1 lists the 18 termite species found in Arizona. Seven termite species of economic significance are discussed and illustrated in more detail below.

Termite Identification

Termites are sometimes referred to as "white ants" but are more closely related to cockroaches than ants [13,33]. Upon superficial inspection, termites can resemble ants, particularly because they may swarm at the same time of year. Winged ants are often mistaken for termite alates. Web spinners (Embioptera) can also be confused with termites. Several key morphological characteristics can be seen with the naked eye that can be used to differentiate termites from other insects (Figure 5). Ants have two pairs of transparent wings of unequal size, while termites have four equal-sized wings that fold over the back. The region of the body behind the wings in ants is "pinched", but this region

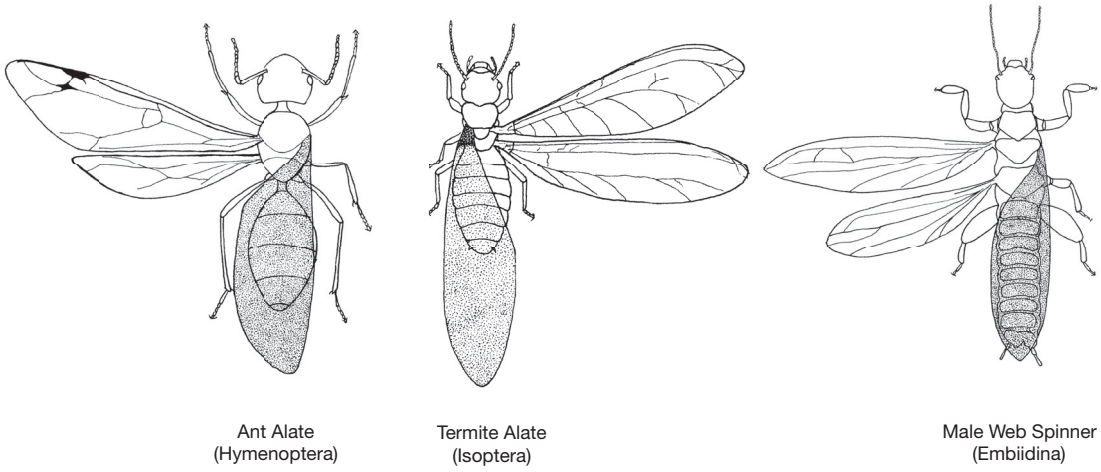

Fig. 5. Key morphological features distinguishing a reproductive ant, a termite alate, and a webspinner.

is broad in termites. Although male web spinners have two pairs of nearly equal-sized wings, they have a pair of cerci at the end of their abdomens, enlarged basitarsi (tarsal segment attached to the tibia) on their forelegs, and asymmetrical genitalia. To aid in the identification of the seven economically important Arizona termites, a dichotomous key using soldiers is found the Appendix.

Arizona termites of economic importance

The Dampwood Termites

***Paraneotermes simplicicornis* (Banks)**: The desert dampwood termite is the only dampwood termite considered a pest of wooden structures in Arizona (Figure 6). It is technically not a dampwood termite as it is classified into the family of drywood termites, Kalotermitidae. The range of this termite extends from southern California to Texas, spanning an area from almost the Pacific coast to near the Gulf of Mexico. From north to south, it ranges from Las Vegas, Nevada to San Blas de Sinaloa, Mexico [23]. This range is almost all arid, semi-desert and desert habitat. Even though it is confined to arid areas, it does not appear that is especially well adapted to dry soil conditions. Laboratory experiments have shown this termite requires high moisture content to thrive in soil [41]. Due to its high moisture requirements, it attacks moist wood below the ground and it nests in and around the food source. The desert dampwood termite also attacks living or partly living desert shrubs and even young citrus trees [3], utilizing the sap of these plants for needed moisture.

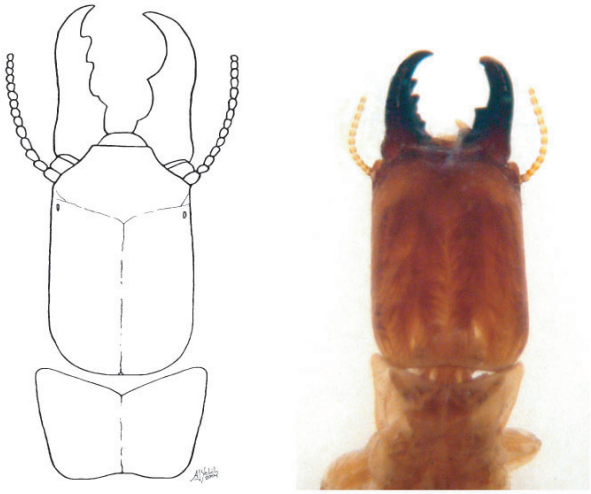

Fig. 6. The desert dampwood termite, *Paraneotermes simplici cornis.*

Castes of the desert dampwood termite can be distinguished from other drywood termites. *P. simplicicornis* soldiers are intermediate in size (5/16-inch to 7/16-inch) with low flat heads (Figures 3, 6), and are brown or yellowish brown. Their mandibles are relatively short and much wider at the base than at the tips (Figure 6). The third antennal segment is not enlarged in this termite. *Paraneotermes* nymphs (workers) have distinctive spotted abdomens. Winged adults are dark brown in both body and wings. In Arizona, adults swarm during late May through September [29]. Their flights are not necessarily associated with the monsoon rains. But they will swarm the following evening after

a strong summer rain. Their flights occur at dusk with flight duration being about one-half hour in length. Resulting colonies are considered small, few upward of 1,400 individuals and typically confined to highly moist buried food sources [23,29].

P. simplicicornis is not a major economic pest. It does commonly attack untreated poles and fence posts. It is capable of doing considerable damage to these structures. Rarely is this termite found in human-made dwellings, and it is generally associated with moist or wet wood when it does infest wooden structures. Infestations are typically located in the baseboards and doorframes of buildings.

The Drywood Termites

There are two important pest species of drywood termites in Arizona: ***Incisitermes minor*** (Hagen), the dark western drywood termite and ***Marginitermes hubbardi*** (Banks), the light western drywood termite (Figure 7 and 8). Both of these species are capable of attacking sound dry wood (Figure 9). These species require no contact with the soil living entirely within their food source. Their moisture requirements are drawn directly from wood. In the process of building their tunnels in wood, they construct "kick holes". These holes are used to eliminate fecal pellets from their galleries. The accumulation of fecal pellets below kick holes is often the first sign of infestation of a wooden structure by drywood termites.

Incisitermes minor is the most widespread and probably the most destructive drywood termite in the western United States [33]. Originally, Hagen in 1858 described it as *Kalotermes minor,* but it was reclassified by Krishna into the genus *Incisitermes* in 1961. It is found naturally in marginal desert areas and within dry washes below 6,000 ft in elevation. Since this termite can be transported in furniture and other wood products, it is often found outside its normal habitat with infestations occurring throughout the United States [33]. Infestations by *I. minor* have been reported along the east coast from New York to Florida, including New Jersey, Maryland, Virginia, North and South Carolina, and Georgia. Along the Gulf Coast, infestations have been reported in Arkansas, Louisiana, and Texas. Its range extends throughout the desert southwest into Arizona, and proceeding west to the Pacific coast, then south down into Mexico and north into central and northern California [21,33]. Given the climatic conditions over this broad geographic range, this termite can tolerate a wide array of temperature extremes.

The dark western drywood termite attacks dead trees, dead branches on living trees, and solid structural wood on wooden buildings. In wooden

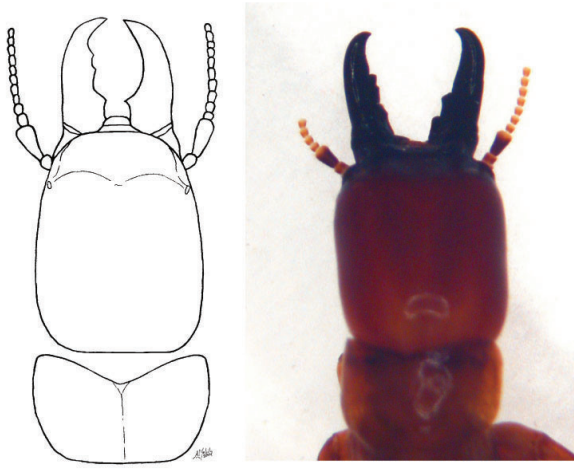

Fig. 7. The dark, western drywood termite, *Incisitermes minor.*

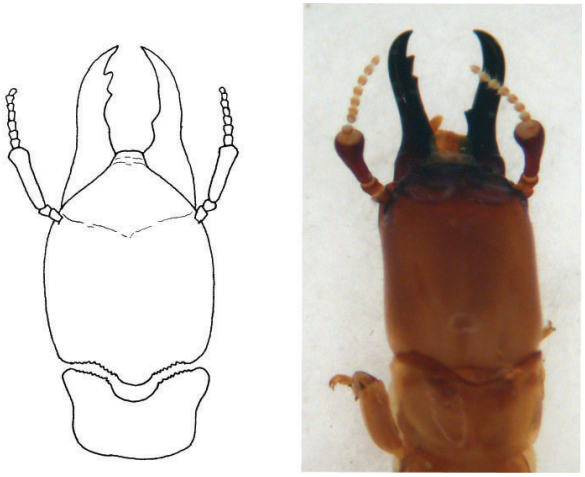

Fig. 8. The light, western drywood termite, *Marginitermes hubbardi.*

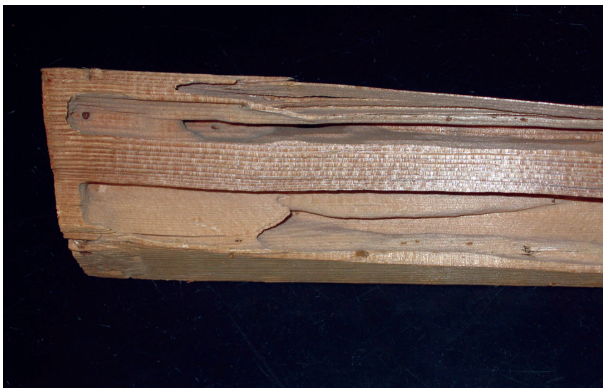

Fig. 9. Drywood termite damage.

structures, this termite does attack flooring, windows, doorframes, soffits, fascia boards, and even roof sheathing [21,28,29]. It is known to infest utility poles, posts, and stored lumber [33]. It has also been found in the sound dead wood of many living trees common to Arizona and California. These trees include sycamore, oak, alder, cottonwood, eucalyptus, willow, and several varieties of fruit trees such as apricot, almond, avocado, citrus, peach, pear, and plum trees [21, 33].

The size of an *Incisitermes minor* termite colony can vary from 2,000 to 3,000 termites, with reports of over 9,000 termites taken from one colony [29]. As compared to subterranean termite colonies, drywood termite colonies are both small and slow to develop. Its soldiers and alates commonly identify the dark western drywood termite. Soldiers of this species have large heavy mandibles, with the basal segment of the antennae slightly enlarged (Figure 7). Dark western drywood alates are about a 1/2-inch long with wings, and have dark brown bodies, reddish brown heads and thoraxes, and smoky-black membranous wings with black veins [21,33]. In Arizona, peak swarming typically occurs on bright sunny days from June through August. The flights do not typically correlate with the rainy season [29]. There are no true workers in this species. Nymphs perform the duties of adult workers. They excavate the galleries in the wood, tend to eggs and young, and feed the king and queen.

Marginitermes hubbardi is found in true desert regions of Arizona and southern California primarily at elevations below 4,000 ft. The range of this termite extends from the southeastern border of California along the Colorado River Valley through central and southern Arizona, and proceeds to down both coasts of the Gulf of California [22]. In Baja California, it ranges along the east coast of the gulf to the tip of the peninsula, while on the Mexican coast of the Gulf of California *M. hubbardi* can be found as far south as the city of Colima. In Arizona, the termite is found at lower and intermediate altitudes such as Phoenix to Tucson. At higher altitudes such as Prescott and Flagstaff, it is replaced by *Incisitermes minor* [21,22].

Several key physical and behavioral characteristics help distinguish this termite from other drywood and subterranean termites. The alates or swarmers of this species are pale yellow with light wings, and are intermediate in size about 1/2-inch with wings. A distinguishing feature of the soldier is the basal third antennal segment, which is elongated and club-like, making the segment almost as long as all the remaining segments combined (Figure 8). This termite is well adapted to dry conditions. Both laboratory and field experiments indicate that *M. hubbardi* tolerates and prefers conditions much drier than *I. minor* [41]. Also in contrast to *I. minor,* alates swarm at dusk undertaking up to 20 flights from June into September [29]. These flights are not associated with rain. The size of individual colonies does vary, and colonies can exceed 2,000 termites [29].

M. hubbardi is a significant drywood pest in Arizona. In the northern part of its range, *M. hubbardi* attacks a wide variety of dry sound wood. In its natural habitat, it attacks cottonwoods along canyons and streambeds [22]. In the southern part of its range although it is commonly infests saguaro skeletons, it is more commonly found in wooden human-made structures than in its natural habitat [22]. Here its damage can be extensive and problematic to the structural integrity of wooden buildings. As large population centers invade its natural range with ever-increasing construction of wood frame homes, this termite will become an increasing pest problem in central and southern Arizona.

The Subterranean Termites

Estimates for termite control in the United States range from 1.5 billion [38] to more than 2.5 billion dollars [6,25]. Control of damage caused by subterranean termites account for 66-80% share of all costs of termite control [6,33]. In Arizona, four species of desert and subterranean termites are economic or potential economic pests. ***Reticulitermes tibialis*** and ***Heterotermes aureus*** are both significant economic pests infesting and damaging homes and other wooden structures. To a far lesser degree, ***Amitermes wheeleri*** and ***Gnathamitermes perplexus*** can occasionally infest and damage wooden human-made structures.

Reticulitermes tibialis, the arid land subterranean termite, belongs to the most widespread and destructive genus of termites within the United States. This arid land subterranean termite ranges over the semi-arid prairies, steppes and deserts of the Great Basin and the Rocky Mountain states [31]. Its range extends in the east as far as Indiana, and in the west into central, southern and Baja California. In Arizona, *R. tibialis* is considered the most widely distributed subterranean termite. It can be found throughout the state. It has been reported as far south as Yuma, northwest to Bullhead city and as far north as Page [8]. It is the most common termite pest in the Flagstaff area [8]. However, it does not appear to favor extreme desert conditions. In the southern part of the state, it is much less common, here *Heterotermes aureus* and *Gnathamitermes perplexus* dominate the drier and hotter Sonoran desert habitat.

The arid land subterranean termite possesses morphological and behavioral traits that serve to distinguish it from other termite species. *R. tibi-*

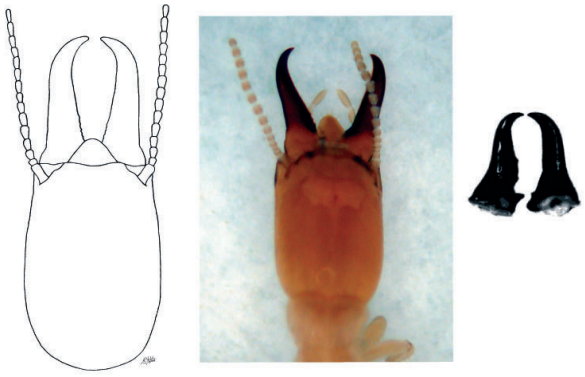

Fig. 10. The arid-land subterranean termite, *Reticulitermes tibialis.*

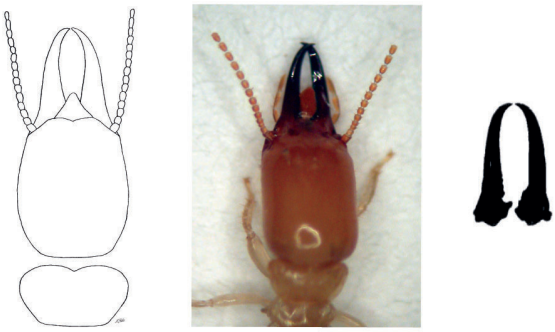

Fig. 11. The desert subterranean termite, *Heterotermes aureus.*

alis soldiers are identified by their short, broad, and dark-colored heads (Figure 10). Conversely, the soldiers of *Reticulitermes hesperus* have a pale, long, and narrow heads. The arid land subterranean termite soldier's mandibles are thick and slightly shorter than the width of its head capsule. This feature serves to distinguish it from the desert subterranean termite, *Heterotermes aureus* (Figure 11). The alates of *R. tibialis* are dark brown to black, and over a 1/4-inch long with almost colorless wings. In contrast, *H. aureus* reproductive adults are much lighter, tan in color. The arid land subterranean termite has two flight seasons. One flight season occurs during the winter, and the other in the summer rainy periods. In Arizona, the flight season in a particular location depends on the elevation of the site. Above 4,000 feet, *R. tibialis* swarms in the summer, usually June and July. In the more arid and hot areas of the state below 4,000 feet, a small number of flights occur in the late winter to spring months between January and March. [29]. Swarming behavior by *R. tibialis* adults is not as commonly noticed as flights by other subterranean termites. Flights occur during daylight hours on sunny days. This behavior is different that other subterranean termites that tend to be night flyers.

Reticulitermes tibialis is an economic pest in the western states. In its natural habitat, this termite does a moderate amount of damage to roots and stems of plants. It can also do substantial damage to human-made structures like untreated posts, utility poles, and wooden buildings. The arid land subterranean termite is not limited to attacking wood on or in the ground due to its ability to build shelter tubes over the foundations of buildings [39]. This behavior allows it to attack structural wood within buildings. However, several behavioral and biological characteristics may moderate the extent of damage done by *Reticulitermes tibialis*. The arid land subterranean termite is much less persistent in building tubes up to wooden structures than other subterranean termites. When it does enter a building, it is more likely to attack moist and decaying wood than dry sound lumber [32]. This in part may be due to its preference for conditions of higher humidity [41].

The most destructive termite in Arizona is ***Heterotermes aureus,*** the desert subterranean termite (Figure 11). It is the most common subterranean termite in the Sonoran desert at elevations below 4000 ft. [8,10,11]. The geographical distribution of the desert subterranean termite stretches from southeastern California through southern Arizona and south into Baja California, Sonora and Sinaloa, Mexico [10,31]. Both temperature and precipitation appear to influence its distribution [8]. Because the desert subterranean termite can tolerate both high temperature and desiccation [8,11], it is capable of inhabiting the hottest driest areas of the Sonoran desert. Paradoxically, its range may be limited by low rather than high temperature [8].

H. aureus is known to attack various types of dead wood. It is a generalist feeder on all woods. These include cactus ribs, desert trees, utility poles, posts, structural timbers in floors and rafters. In its natural habitat, it prefers desert hackberry and cholla wood [11]. Structures infested with the desert subterranean termite can be identified by the presence of "drop tubes" from the ceiling and or "mud shelter tubes" built over inedible materials like foundation stem walls (Figure 12). These mud tubes can be distinguished from tubes constructed by the arid land subterranean termite. The desert subterranean termite builds tubes that are small, strong, and nearly airtight with a circular cross-section [31]. The walls of these arched tubes are lined with fecal matter acting as a plaster to strengthen the tube [31]. This light yellow fecal material and frass gives their mud tubes a characteristically light color. *Reticulitermes tibialis* tends to build flatter, less solidly constructed mud tubes that appear dirty dark brown in color [31].

Fig. 12. Shelter tubes on a building foundation.

Identification of subterranean termites to species level is usually accomplished by close examination of either its soldiers or its winged adults. Soldiers of the desert subterranean termite have mandibles that are 1/16-inch long, slender and nearly straight {Figures 3,11). When compared to *Reticulitermes,* the head of a *Heterotermes* soldier appears longer and more slender, while *Gnathamitermes* and *Amitermes* soldiers have smaller more oval heads (Figure 3). Alates or swarmers of the desert subterranean termite are pale in color with nearly transparent wings, and have yellow to yellow-brown bodies [31,33]. They are approximately 1/4-inch long without wings and almost a 1/2-inch long with wings. These swarmers generally take flight at dusk after a rain during the monsoon season from July to September. Alates are rarely found within structures [11, 29].

It has been suggested that, if not for its limited distribution in the United States, *Heterotermes aureus* would be one of the most destructive termites in the country [11,31,33]. The desert subterranean termite displays several biological and behavioral characteristics that facilitate its ability to do considerable economic damage to wooden structures. Because of its tolerance for high temperature and very dry conditions, it can do serious damage to dry sound structural wood. When attacking a wooden structure, it is far less dependent than Reticulitermes species on finding moist and decaying wood. It can penetrate hardwoods readily, and has been reported to attack Sonoran ironwood [31]. It is persistent and skilled in building shelter tubes from the ground underneath buildings to access structural lumber. These tubes can easily extend over a foundation and up a wall, often being in excess of twenty-four inches in height [31]. These traits combine to make it the most destructive termite in Arizona, and a serious economic pest to our ever-growing urban areas.

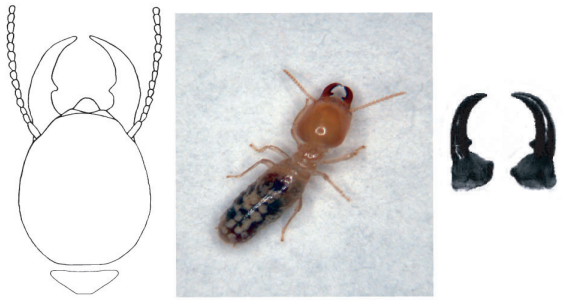

Fig. 13. Wheeler's desert termite, *Amitermes wheeleri.*

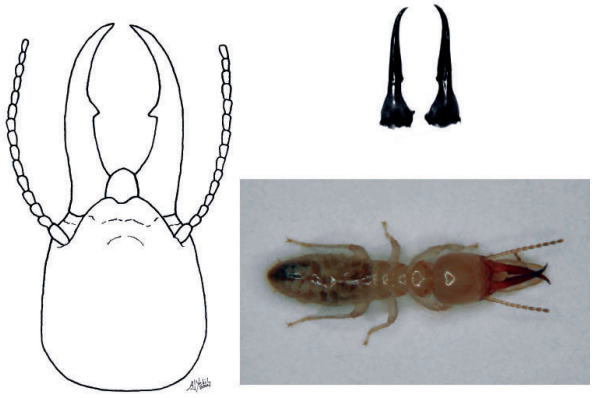

Fig. 14. The tube-building desert termite, *Gnathamitermes perplexus.*

Amitermes wheeleri or Wheeler's termite (Figure 13), and ***Gnathamitermes perplexus*** (Figure 14) are two subterranean termites found in Arizona that can occasionally be nuisance pests.

These termites are typically restricted to desert and arid lands, and have been designated by Light as "desert termites" [20]. Both termite species belong to the family Termitidae. *G. perplexus* is found throughout Arizona, southern Nevada, southern California, far-western Texas, and northern Mexico [11,15]. This termite is extremely common throughout the Sonoran desert. Here it is an important decomposer feeding on a variety of dead grasses, weeds, small shrubs, and even "cow chips". *G. perplexus* builds "mud tubes" of sand, soil, and feces over desert shrubs, dead wood and grasses. Under the cover of these shelter tubes, it will eat away the exterior weathered portion of a desert shrub [20]. It is capable of eating away entirely smaller shrubs and grasses leaving only its hollow tubes [20]. *G. perplexus* plays an equally important role in the Sonoran desert ecosystem in aerating the soil horizon. This termite moves considerable quantities of soil to the surface annually [15], and like other termites breaks down and recycles organic material. Wheeler's termite is found throughout the southwest as

its range includes southeastern California, southern Nevada, Arizona, Texas, and western Mexico [11]. It prefers habitats near washes and dry-stream beds. Two behavioral traits distinguish this termite from *Gnathamitermes perplexus*. One, it does not construct exposed galleries. Two, it does eat wood beyond the weathered surface [20]. Typically, it will attack partially buried decaying wood extending its underground galleries over the outside of the wood.

Amitermes wheeleri and *Gnathamitermes perplexus* are identified, like other termites, by their alates and soldiers. Size and color will distinguish the *Gnathamitermes* alates from the winged adults of *Amitermes. Gnathamitermes perplexus* alates are large, a little over 1/2-inch long with wings, and about 1/3-inch long without wings. The head of this adult is large and dark brown with medium size eyes and ocelli, while the thorax is dark brown. The abdomen is distinctive with alternating dark brown and cream-colored bands. Alates of this species usually swarm in the summer months at night often after rain showers. *Gnathamitermes* soldiers have sub-rectangular heads that are nearly as broad as long, antennae that are conspicuously darkened distally, and mandibles nearly straight except for the tips (Figure 14). The mandibles are as long or longer than the head with an obvious inner tooth that is below the middle of the mandible or jaw. Soldiers of Wheeler's termite have heads that are longer than broad, antennae that are not conspicuously darkened distally, and mandibles that are shorter than the head. The mandibles are curved throughout with a large cone-shaped tooth projecting inward near the base of the jaw. The obvious inner tooth at the base of the each jaw is key morphological trait distinguishing this soldier from other termites (Figures 3 and 13). *Amitermes wheeleri* alates are small, typically less than 7/16-inch long with wings, and about 1/5-inch to 1/4-inch without wings. They are dark brown in color throughout the head, thorax and abdomen. Their heads are small with a large, but long and narrow fontanel. These swarmers take flight in summer months after rains both at dawn and dust.

Neither Wheeler's termite nor *Gnathamitermes perplexus* are serious economic pests. They will not cause structural damage to a home. *Gnathamitermes perplexus* is capable of constructing "mud tubes" onto wooden structures or plants. Protected by these flatten tubes of soil and feces, they will feed on the exterior layer of wood. However, this damage is typically only cosmetic in nature. *Amitermes wheeleri* build dark carton over their feeding sites. The homeowner may on occasion encounter this carton on a dead cholla stump in contact with the soil or at the base of Mesquite tree or on a fence post.

As with *Gnathamitermes perplexus,* chemical treatment is not necessary unless Wheeler's termite is found in a structure.

Termite Detection

Even though termite colonies are made up of numerous individuals, termites are quite cryptic spending most of time underground or inside wood. When termites infest a structure, it is necessary to make an accurate assessment of the extent of infestation before invoking treatment options. The primary method inspection is visual searching or probing of wood [33]. The real efficiency of visual searches is not known. Non-visual alternatives have been developed to assess drywood and subterranean termite infestations. Detection by acoustic emissions has shown positive results in both laboratory and field investigations [7, 16, 19, 33, 34]. Methane gas and water vapor detection devices have also been used to detect both drywood and subterranean termites [18,19]. Canine olfaction is yet another method employed to locate termite infestations [18,19, 33, 32]. Termite detection dogs can detect termites often missed by visual inspection and wood probing techniques. However, the cost of training and certification of canines and their handlers is quite high. Microwaves, infrared, and laser technologies may provide devices that allow noninvasive searching of entire walls in the future [19]. However, all these devices have drawbacks and present higher costs than the industry standard "boots on the ground" visual inspection of the premises.

How can a homeowner tell if their home is infested with termites? The homeowner should inspect his/her home at least once or twice a year for signs of termite activity. These signs include: mud tubes on walls particularly in storage areas, holes in wood that have appeared since a last inspection, pellets or sawdust that keeps coming back, piles of wings near light sources, and swarming insects. Typical drywood termite damage is pictured in Figure 9. If there is any indication of infestation, the homeowner should consider requesting a professional inspection (there maybe a fee for this service). Check with friends, neighbors, the Better Business Bureau or the Structural Pest Control Commission for information/recommendations. If an infestation is found, the termite control method of choice will depend on the type of termite species involved and its location within or outside of the structure. ***Consult a professional for all the current control options.***

Termite Management

The management of termites consists of prevention and treatment. As a homeowner there are several options to prevent termites from getting into your home. In the ***pre-construction phase***, the following practices should be used:

- Remove all cellulose materials like stumps and large roots from within 25 ft of the structure;
- Insure that there is adequate drainage away from the house;
- Insist on level and adequate compaction of the soil beneath the concrete;
- Avoid stucco below grade;
- Make sure the concrete is poured within 24 hours of the termiticide application.

In the ***post-construction phase,*** inspect your home twice a year or better yet, employ a pest management professional (PMP) to do an annual inspection. The practice of repeated visual inspections insure that termite infestations will be promptly detected once termites have invaded the home. This practice allows control methods to be employed contemporaneous to the infestation, reducing the risk of serious structural damage to the home. In the event that you do find termites in your house - ***don't panic.*** In general, the termites found in Arizona usually take some time to become established, and severe structural damage to the home can be avoided by prompt remedial control. Control options are determined by the species. In the case of drywood termites, wood replacement or fumigations can be used. For subterranean termites, the options are liquid termiticides or a baiting program. Liquid termiticides applications have been the standard in the industry for decades and consist of rodding, trenching, and sub-slab application of liquid termiticide around the home. Baiting systems have been introduced into the market place within the last 10 years. They require monitoring of a cellulose bait matrix that the termites feed on and die. For more details on control strategies consult the University of Arizona extension publications: " Termite Management for Homeowners", "Cost of Liquid Termiticides", and "Drywood Termites".

References Cited

1. Badertscher, S., C. Gerber and R.H. Leuthold. 1983. Polyethism in food supply and processing in termite colonies of *Macrotermes sub hyalinus* (Isoptera). *Behav. Ecol. Sociobiol.* 12: 115-119.

2. Bignell, D.E. 2000. Introduction to symbiosis, pp.189-208. In: T. Abe, D.E. Bignell and M. Higsahi, eds., *Termites: Evolution, Sociality, Symbioses, and Ecology*. Kluwer Academic Publishers, Dordrecht, The Netherlands.

3. Bynum, W.M. 1951. The desert damp-wood ter mite in the lower Rio Grande valley of Texas. J. *Econ. Entomol.* 44: 996-997.

4. Costa-Leonardo, A.M. and Kitayama, K. 1991. Frontal gland dehiscence in the Brazilian termite *Serritermes serrifer* (Isoptera, Serritermitidae). *Sociobiology* 19: 333- 338.

5. Edwards, R. and Mill, A.E. 1986. *Termites in buildings. Their biology and control*. Rentokil Ltd., West Sussex, UK.

6. Forschler, B.T. and T.M. Jenkins. 2000. Subterra nean termites in the urban landscape: Understanding their social structure is the key to successfully implementing population management using bait technology. *Urban Ecosys tems.* 4: 231-251.

7. Fujii, Y., M. Noguchi, Y. Imamura and M. Tokoro. 1990. Using acoustic emission monitoring to detect termite activity in wood. *Forest Prod. J.* 40: 34-36.

8. Haverty, M.I., and W.L. Nutting. 1976. Environ mental factors affecting the geographical distribution of two ecologically equivalent termite species in Arizona. *Amer. Mid. Nat.* 95(1): 20-27.

9. Hinze, B. and R.H. Leuthold. 1999. Age related polyethism and activity rhythms in the nest of the termite *Macrotermes bellicosus. Insectes soc.* 46: 393-397.

10. Jones, S.C., M.W. Trosset, and W.L. Nutting, 1987. Biotic and abiotic influences on foraging of *Heterotermes aureus* (Snyder) (Isoptera: Rhinotermitidae), *J. Environ. Entom.* 16(3): 791-795.

11. Jones, S.C. and W.L. Nutting. 1989. Foraging ecology of subterranean termites in the Sonoran desert, pp. 79-106. In: J.O. Schmidt, ed.,

Special Biotic Relationships in the Arid South west. University of New Mexico Press, Albuquerque, N.M.

12. Jones, S.C. 1990. Delineation of *Heterotermes aureus* (Isoptera: Rhinotermitidae) foraging territories in Sonoran desert grassland. *J. Environ. Entom.* 19(4): 1047- 1054.

13. Kambhampati, S. and P. Eggleton. 2000. Taxonomy and phylogeny of termites. In: *Termites: Evolution, Sociality, Symbioses, and Ecology* (T. Abe, D.E. Bignell and M. Higsahi, eds.), pp.1-23, Kluwer Academic Publishers, Dordrecht, The Netherlands.

14. Krishna, K. 1961. Generic revision and phylo generic study of the family Kalotermitidae (Isoptera). *Bulletin of American Museum of Natural History* 122: 303-408.

15. La Fage, J.P. 1974. Environmental factors controling the foraging behavior of a desert subterrnean termite, *Gnathamitermes perplexus* (Banks). Masters thesis, University of Arizona, Tucson, AZ.

16. Lemaster, R. L., F. C. Beall & V. R. Lewis. 1997. Detection of termites with acoustic emission. *Forest Prod. J.* 47: 75-79.

17. Lewis, V. R., and M. I. Haverty. 1996. Evaluation of six techniques for control of the western drywood termite (Isoptera: Kalotermitidae) in structures. *J. Econ. Entomol.* 89: 922-934.

18. Lewis, V. R., C. F. Fouche & R. L. Lemaster. 1997. Evaluation of dog-assisted searches and electronic odor devices for detecting the Western subterranean termite. *Forest Prod. J.* 47 (10): 79-84

19. Lewis, V.R. Alternative Control Strategies for Termites. http://www.cnr.berkeley.edu.lewis/alterna.pdf.

20. Light, S.F. 1934. The desert termites of the genus, *Amitermes,* pp. 199-205. In: C. A. Kofoid, ed., *Termites and Termite Control.* University of California Press, Berkeley, CA.

21. _____. 1934. The distribution and biology of the common dry-wood termite, *Kalotermes minor,* pp. 210-233. In: C. A. Kofoid, ed., T*ermites and Termite Control.* University of California Press, Berkeley, CA.

22. _____. 1934. The southern and mountain drywood termites, *Kalotermes hubbardi* and *Kalotermes marginipennis,* pp. 266-268. In: C. A. Kofoid, ed., *Termites and Termite Control.* University of California Press, Berkeley, CA

23. _____. 1934. The desert damp-wood termite, *Paraneotermes simplicicornis,* pp. 311-313. In: C. A. Kofoid, ed., *Termites and Termite Control.* University of California Press, Berkeley, CA.

24. Light, S.F. and A.L. Pickens. 1934. American subterranean termites, their classification and distribution, pp. 150-156. In: C. A. Kofoid, ed., *Termites and Termite Control.* University of California Press, Berkeley, CA.

25. Mannes, C. 2005. Protect your largest investment: check home for termites. National Pest Management Association, http//www.pest world.org/article.asp?ArticleID=20.

26. Noirot, C. 1969. Formation of Castes in the Higher Termites, pp. 311-350. In: K. Krishna and F.M. Weesner, eds., *Biology of Termites, Vol.1* . Academic Press, New York, N.Y.

27. Noirot, C. and J.P.E.C. Darlington. 2000. Termite Nests: Architecture, Regulation and Defence, pp.121-139. In: T. Abe, D.E. Bignell and M. Higsahi, eds., *Termites: Evolution, Sociality, Symbioses, and Ecology.* Kluwer Academic Publishers, Dordrecht, The Netherlands.

28. Nutting, W. L. 1968. Termites of Arizona. *Prog. Agric. Arizona.* 20:8-9.

29. Nutting, W. L. Unpublished data.

30. Pearce, M. J. 1997. *Termites: biology and pest management.* CABI Publishing, New York, NY.

31. Pickens, A.L. 1934. The barren-lands subterranean termite, *Reticulitermes tibialis,* pp.184-186. In: C. A. Kofoid, ed., *Termites and Termite Control.* University of California Press, Berkeley, CA.

32. Pickens, A.L., and S.F. Light. 1934. The desert subterranean termite, *Heterotermes aureus,* pp.196-198. In: C. A. Kofoid, ed., *Termites and Termite Control.* University of California Press, Berkeley, CA.

33. Potter, M. F. 1997. Termites. In: D. Moreland, J.W. Chapman and R.M. Corrigan, ed.s, *Mallis Handbook of Pest Control,* 8th Ed., Mallis Handbook & Technical Training Company, Cleveland, Ohio.

34. Scheffrahn, R. H., W. P. Robbins, P. Busey, N-Y. Su & R. K. Mueller. 1993. Evaluation of a novel, hand-held, acoustic emissions detector to monitor termites (Isoptera: Kalotermitidae, Rhinotermitidae) in wood. *J. Econ. Entomol.* 86: 1720-1729.

35. Su, N-Y. & R. H. Scheffrahn. 1990. Economically important termites in the United States and their control. *Sociobiology* 17: 77-94.

36. Su, N-Y. and R. H. Scheffrahn.1993. Laboratory evaluation of two chitin synthesis inhibitors, hexaflumuron and diflubenzuron, as bait toxicants against Formosan subterranean termites and eastern subterranean termites (Isopters: Rhinotermitidae). *J. Econ.Entomol.* 86: 1453-1457.

37. Su. N-Y. and R. H. Scheffrahn. 1998. A review of subterranean termite control practices and prospects for integrated pest management programmes. *Integrated Pest Management Re views* 3: 1-13.

38. Su, N-Y. and R. H. Scheffrahn. 2000. Termites aspests of buildings, pp.437-453. In: T. Abe, D.E. Bignell and M. Higsahi, ed.s, *Termites: Evolution, Sociality, Symbioses, and Ecology.* Kluwer Academic Publishers, Dordrecht, The Netherlands.

39. Snyder, T.E. 1934. American subterranean termites other than those of the Pacific coast, pp. 187-195. In: C. A. Kofoid, ed., *Termites and Termite Control.* University of California Press, Berkeley, CA.

40. Weesner, F. 1965. *The Termites of the United States - A Handbook.* The National Pest Control Association, 250 West Jersey St, Elizabeth, NJ.

41. Williams, O.L. 1934. Some factors limiting the distribution of termites, pp. 42-49. In: C. A. Kofoid, ed., *Termites and Termite Control.* University of California Press, Berkeley, CA.

Appendix

Key to the Seven Most Important Arizona Termites – Soldiers

1. Large termite, 5/16 to 7/16 inches long with large heavy mandibles 2
   Small termite, 3/16 to 1/4 inches long with slender light mandibles.....3

2. Antennae is simple, the third antennal segment is not noticeably enlarged
..... *Paraneotermes simplicicornis* (Figures 3,6)

2`. Third (1st segment not always visible from dorsal view) segment of antenna enlarged, club-.....
shaped, but not as long as the next four antennal segments. ..... *Incisitermes minor* (Figures 3,7)

2``. Third segment of antenna greatly enlarged, as long as the remainder of the antenna
..... *Marginitermes hubbardi* (Figures 3,8)

3. Mandibles curved inward, with an obvious inner tooth..... 4

3`. Mandibles nearly straight and very slender at point, nearly as long as head capsule; head long, slender, and light tan in color…… ....*Heterotermes aureus* (Figure 3, 11)

3``. Mandibles nearly straight, heavier, wide at base, and curved at the point, mandibles generally .....
shorter than width of head capsule; head short, broad, and dark in color..... .....
..... *Reticulitermes tibialis* (Figure 3,10)

4. Incurved mandibles, much shorter than head, mandibles curved throughout, inner tooth large, ...
cone shaped, and projects inward..…..... .....*Amitermes wheeleri* (Figures 3,13)

4`. Incurved mandibles at the tips, mandibles nearly as long as head, head sub-rectangular, sides .....
faintly convex, inner tooth less acute..... .... *Gnathamitermes perplexus* (Figures 3,14)

Table 1. Termite species commonly found in Arizona.

Habitat Type	Family	Species	Common Name[2]
Dampwood	Hodotermitidae	*Zootermopsis laticeps (* Banks)	Southern rottenwood termite
Drywood	Kalotermitidae	*Pterotermes occidentis* (Walker)	
	Kalotermitidae	*Incisitermes banksi* (Snyder)	
	Kalotermitidae	*Incisitermes minor* (Hagen)	Dark, western drywood termite
	Kalotermitidae	*Marginitermes hubbardi* (Banks)	Light, western drywood termite
	Kalotermitidae	*Paraneotermes simplicicornis*	Desert dampwood termite
Subterranean	Rhinotermitidae	*Heterotermes aureus*	Desert subterranean termite
	Rhinotermitidae	*Reticulitermes tibialis* [1]	Arid-land subterranean termite
	Termitidae	*Amitermes coachellae*	Coachella desert termite
	Termitidae	*Amitermes emersoni*	Emerson's desert termite
	Termitidae	*Amitermes minimus*	
	Termitidae	*Amitermes parvulus*	
	Termitidae	*Amitermes pallidus*	
	Termitidae	*Amitermes silvestrianus*	Silvestri's desert termite
	Termitidae	*Amitermes snyderi*	Synder's desert termite
	Termitidae	*Amitermes wheeleri*	Wheeler's desert termite
	Termitidae	*Gnathamitermes perplexus*	Tube-building desert termite
	Termitidae	*Tenuirostritermes tenuirostris*	

1. Recent work, shortly to be published, by Dr. Michael I. Haverty, USDA Forest Service, provides evidence of four species of *Reticulitermes* present in Arizona.
2. Common names do not denote common names approved by the Entomological Society of America.

THE UNIVERSITY OF
ARIZONA®
COLLEGE OF AGRICULTURE
AND LIFE SCIENCES

AZ 1369