Relationships Among Molt, Social Aggression and Disease

Impact on Wild and Captive Gouldian Finches

By Rob Marshall

This article is adapted from a paper titled "A Relationship Between the Molt and Airsac Mite Infection in the Gouldian Finch," which the author presented to the 2009 Annual Conference of the Australian Chapter of Association of Avian Veterinarians.

Red-headed male Gouldian Finches are seen here dominating the fresh Newcastle grass seed spray.

Historical and Research Review

Scientific research of the Gouldian finch began in 1989 after the Northern Territory Government recognized that the wild population had rapidly declined over the previous two decades. The Gouldian finch was listed as an endangered species at this time. Research initially focused on breeding biology, population trends, disease factors, and the impact of fire on seed resources. This work revealed that the Gouldian finch relied upon a restricted seed diet and that the key wet season grasses were patchily distributed and fire, grazing and rainfall significantly affected seed production of these grasses.

More recent research examined the foraging behavior of Gouldians and the consequences of assortative breeding (i.e. a preference of Gouldian finches to select similar head colored mates). Twenty years of scientific research have now revealed significant findings but our understanding of the Gouldian finch remains limited.

Researchers have presented several possible causes for the rapid decline of the wild populations. These include commercial trapping for aviculture, habitat destruction associated with land clearance by fire and destruction of some important perennial grasses by grazing cattle, as well as feral pigs and wild buffalo. Behavioral and genetic differences between the red-headed and black-headed Gouldian finches are now being considered as an important cause of the decline. Death from airsac mite infection is also believed to be involved with declining numbers, but the exact reasons for an increased susceptibility to this infection have not been investigated.

Trapping

Trapping was vigorous for almost three decades from 1960–1988 and provided many thousands of Gouldian finches for aviculture. Although trapping had a significant effect on Gouldian numbers and populations during this time, the population should have rebounded over the ensuing 20-year period because of their prolific breeding ability. This has not occurred and at the present time numbers in remaining populations are stable but remain low. An estimated 2500 birds remain in the wild.

Habitat Destruction

Altered fire regimes have had a serious effect on the seeding grasses and nest holes available to Gouldian finches and is believed to be the single most important reason why Gouldian finch numbers have not rebounded since trapping became illegal in 1988.

The loss of traditional fire burning practices over the past 40 years appears to be responsible for the destruction of essential understory grasslands that provide wild populations with a reliable food resource. The loss of traditional knowledge occurred when cattle stations no longer employed aborigines following legislation in 1966 that gave them the right to receive equal pay as white Australian station hands. Before this time, aborigines worked for food and lodgings, and imparted their traditional knowledge of burning practices to the landowners.

Traditional fire burning practice maintains the habitat of the Gouldian finch by patch burning. Patch burns are low-heat fires, lit in the morning during the late wet season or early dry season. This traditional fire method has a positive effect on the environment. Patch burning helps regenerate several of the perennial wet season grasses (e.g. Cockatoo grass, Curly Spinifex) favored by Gouldian finches.

Non-traditional fire practices produce large hot wildfires intended to clear the land of undergrowth and native grasses, thereby allowing introduced drought resistant grasses (e.g. Buffel grass) favored by cattle to establish themselves more readily. These uncontrolled fires destroy important perennial grass tussocks and nesting habitats. However, excluding fire completely would not be beneficial, as traditional fire practices have a positive influence on the quantity of seed produced by Cockatoo and Curly Spinifex grasses.

Grazing and destruction of perennial grass plants (Cockatoo grass and Ribbon grass) by feral pigs and buffalo have also reduced the amount of food available to Gouldian finches during the wet season, which has a negative effect on breeding outcomes.

Reduced availability of critical wet season grass seed resources is due to changes in land use and consequent changes in grazing and fire regimes. These changes when combined with natural fluctuations in seasonal rainfall are thought to be involved with the decline of the Gouldian finch in its natural environment. As yet, there are no clear links between resource scarcity and endangered status (Dostine

Above left, four new primary flights feathers are seen in this wing. No secondary flights have been molted yet. Above right, pin feathers on the head may occur in some birds toward the end of the molt period. This may be a healthy or unhealthy finding.

& Franklin 2002; Fraser 2000; Crowley & Garnett 1994). In other words, starvation because of lack of food supply is not believed to be the cause of the decline in Gouldian numbers. Therefore other reasons must account for the decline in numbers.

Behavioral and Genetic Issues

In 2009 research carried out by Pryke and Griffith revealed behavioral differences between the red-headed and black-headed Gouldian finches that may account for the greater number of black-headed birds in nature, even though the red head color is genetically dominant over black heads.

It has been suggested that in the distant past the red-headed and black-headed populations were separated geographically and existed as two distinct sub-species before coming back into contact again to co-exist together as a single population. The geographic separation may also explain the distinct behavioral differences displayed by the different head color.

Both male and female red-headed birds are more aggressive than the black-headed birds. The more competitive nature of red-headed birds may be explained by a more challenging environment. The limited availability of nest sites, water and food resources in the region they inhabited during their geographic separation would have made them more aggressive in order to survive. The more passive nature of black-headed birds may reflect habitation in a plentiful and less competitive environment.

Previous research has shown that there is a higher mortality of daughters as compared to sons when interbreeding between different species, subspecies or races, Pryke and Griffith found that fewer Gouldian offspring survived when red-headed and black-headed birds were paired together compared to when pairs of the same head color were allowed to breed.

There are three possible head colors for wild-type Gouldian finches—red, yellow and black. Black-headed birds comprise approximately 70 percent of the wild population, even though the red-headed birds are more aggressive and the red color is a genetically dominant feature. The red heads have a huge dominance advantage created by their higher testosterone levels, allowing them to occupy the best nesting hole, be first to drink at water holes etc. Unfortunately, the high levels of male sex hormones in the red-headed birds also suppress immunity and predisposes them to a higher mortality rate. The higher mortality rate of the red-headed birds has resulted in a greater population of black-headed birds.

Head color is also very important when Gouldians are selecting their mates. Female Gouldian finches choose their mates based on several head features including head plumage color. They prefer a mate with the same head color. This preference has been found to be highly significant for the survival of offspring. Pryke and Griffith confirmed that genetically incompatible pairs experience a 40.2 percent greater mortality of sons and an 83.8 percent greater mortality of daughters than in broods produced from genetically compatible matched pairs (i.e. same head colors). Additionally daughters produced from mixed matings, where parents differ in head color, suffer from genetic incompatibilities between their parents that cause about 84 percent to die young. It was also found that female Gouldian finches paired with mismatched males produced significantly more male chicks (82.1 percent), whereas females in matched pairs produced nearly equal numbers of both sexes (45.9 percent males).

This series of studies revealed that female birds choose the sex of their offspring independent of genetic forces. This new body of work reveals a behavioral and genetic incompatibility between red-headed and black-headed birds, which may provide the answer behind the failure of Gouldian populations to recover after Gouldian numbers were dramatically reduced by trapping. At this time it is likely that a greater proportion of females mated unwillingly with incompatible mates (i.e. red-headed and black-headed pairings), because of a lack of mate choice.

Higher numbers of these incompatible pairs would have a negative impact on the ability of the local population to increase, due to the reduced likelihood of offspring survival and an increased number of male offspring surviving (Pryke & Griffith, 2009). The end results are a decrease in females passing into the next and future generations (Pryke & Griffith, 2009).

Airsac Mite Infection

Airsac mite infections have also been thought to play a role in the decline of the Gouldian finch (Tidemann & Woinarski 1994). It has been speculated that the impact of S. tracheacolum might be exacerbated during periods of physiological stress associated with the molt and food shortages at the onset of the wet season (Lane & Goodfellow 1989 cited in O'Malley 2006a; O'Malley 2006).

Infection with airsac mite S. tracheacolum has a rapid effect on the health and survivability of captive Gouldian finches. Airsac mite infections, which often appear during the molt and breeding period in captive populations, are likely to be involved with the decline of the wild Gouldian finch population as well. However, because a symbiotic relationship between Gouldian finches and airsac mites exists, any devastating effect on the wild population would require a set of circumstances that dramatically affect immunity.

In captive Gouldian finches, airsac mite infection is likely to occur when immunity is compromised during periods of overlapping stress, which are most likely to occur during the natural stress periods of molt, breeding and adolescence. For example, airsac mite infection is likely when a compressed molt is abruptly interrupted and when breeding birds and their offspring experience food shortages. Importantly, red-headed birds are more likely to succumb to airsac mite infection.

Yellow head color is an autosomal recessive trait, but is expressed only when the bird also has the red gene. Yellow-headed birds are very rare in the wild, consisting of fewer than one individual per 1,000. Black head is a sex-linked recessive trait. In nature, black-headed birds outnumber red-headed birds three to one. Red color is also a sex-linked trait and dominant to black head color. Though black-headed pairs produce 100 percent black-headed offspring, red-headed pairs may produce black-headed offspring.

Special Features of the Gouldian Molt

The time taken for the Gouldian finch to complete the molt is rapid compared to masked and long-tail finches which occurs at the same time, (Franklin et al. 1998) and thought to reflect the more mobile and dispersive nature of the Gouldian finch (Tidemann and Woinarski 1994).

Gouldian finches have adapted to an environment under the control of a tropical weather system that divides the year into a wet and dry season—where the birds breed and molt at different times than other finches. A rapid molt appears to be an evolutionary adaptation to an unpredictable climate and tropical woodland breeding environment. This adaption makes it necessary for the wing molt to be completed before the end of the dry season. The advantage is that the molt is completed before frequent seed shortages and prior to torrential rains of the wet season, when foraging activity is reduced and the ability to fly long distances in search of alternative food supplies is restricted.

A Rapid Molt

The rapid nature of the Gouldian molt has been noted by scientific researchers (Franklin et al. 1998) and is the Gouldian's most notable feature. Conflicting scientific reports regarding the molt in wild Gouldian finches reflect a variable rate of progress rather than any observation failing. Milton Lewis (2001) has noted both adults and juveniles molt during September, October and November with most of the wing flight feathers being replaced during October and the entire molt being completed by mid-December.

The molt for Australian captive Gouldians is completed most rapidly when they are housed in temperate climatic regions of Australia, have finished breeding activities by June and are provided with a perfect diet. Under these conditions, the wing molt is completed late in October and the head molt by the last week in November. Under less than ideal conditions, molt may continue until the end of December.

From Milton Lewis' research the early completion of the wing molt appears to be a significant event that guarantees strong flight by the onset of the wet season when heavy rains make foraging activities more demanding. Tidemann and Woinarski (1994) record that the wing molt period finishes in November. This finding compares favorable to the time when the wing molt is completed for Gouldian finches housed in Australian aviaries. These two researchers also mention that seed shortage can occur near this time, a finding that supports a need for Gouldian finches to complete their wing molt as rapidly as possible.

For wild Gouldian finches, breeding behavior starts as they seek out hollows late in the wet season (March and April) when a drop in humidity stimulates the germination of Sorghum grasses and the release of sex hormones that initiate breeding condition.

The total rainfall and extent of the wet season varies from one year to another, so that Gouldian finches are both seasonal and opportunistic breeders. During drought periods, the extent of the wet season is truncated whereas during good seasons the amount of rainfall and extent of the season may be prolonged resulting in up to three clutches of eggs to be produced during a breeding season.

The amount and timing of rainfall during the wet season influences not only breeding success (Dostine et al. 2001) but also has a direct impact on the ability of Gouldian finches to complete their molt as quickly as possible. The start and extent of their breeding activity coincides with a period of peak resource availability within their habitat. Following good wet seasons, plentiful supplies of native sorghum and other fallen seeds (Dostine & Franklin 2002; Dostine et al. 2001; Goodfellow 2005; Tidemann 1993b, 1996; Tidemann et al. 1993) provide nestlings and fledglings with a reliable food resource that remains into the molt period.

Woinarski and Tidemann (1992) noted that the Gouldian finch is more vulnerable to drought during a molt than other co-occurring finch species because it is molting at a time when seed shortages may occur. The molt is a time during which birds may experience physiological stress, as it is a highly energetic process. The rapid molt of Gouldian finches renders them more vulnerable to the effects of stress, because there is a greater energetic cost involved with a rapid molt than a normal molt (Guillemette 2007).

Although Gouldian finches have a more restricted diet compared to other co-occurring granivorous birds (Dostine & Franklin 2002; Fraser 2000; Crowley & Garnett 1994), the seeds of the annual grasses (e.g. Sorghum spp., Sarga spp., Vacoparis spp. Fire grass etc.) they seek, and available to them for most of the molt period provide a higher quality of nutrient resource than early wet season perennial grasses such as Cockatoo grass and curly Spinifex grass.

It is thought that the critical period for physiological stress for wild Gouldian finches occurs at the end of the dry season and onset of the wet season when food supply may be very low during drought. This is a time when the flight feathers are also being replaced.

The length of time food supply is scarce may vary according to the pattern of rainfall in the wet season and the dry season fire regime. A potential to slow down or accelerate the growth of new feathers is a notable feature of the Gouldian molt that has been observed in captive but not recorded in wild birds. This adaptive feature—that is also likely to occur in nature—allows the rate of progress of molt to increase or decrease according to the availability of nutritional resources and changing climatic conditions.

Providing additional nutrition via a soft food mix helps to accelerate the progress of the molt in captive Gouldians. The molt may also be delayed (slow down) when nutrient resources are lacking, during excessively cold or hot weather, when breeding activities extend into the molt period or by disease. In nature, with an uncertain food supply, physiological stress in the Gouldian is avoided by its ability to accelerate or slow down the molt.

In captive birds, a compressed molt is the visible sign of an accelerating molt, whereas a delayed molt refers to a molt that is progressing slowly. The concepts of a compressed and delayed molt have not been discussed in Gouldian finches before. This paper details my understanding of a delayed and compressed molt in Gouldian finches, their relationship to each other and disease with possible links to the decline of wild populations.

The Molt in Captive Gouldian finches

The molt of captive Gouldian finches is an annual seasonal event with a starting time that may vary slightly depending upon local climatic conditions. In Australia captive Gouldian finches may start to molt as early as July. Across the Northern Hemisphere the molt should start in January. A loss of the first (most proximal) primary flight feather heralds the start of the molt period; an occasion that often goes unnoticed because no other feathers are molted and very few feathers are noticed on the aviary floor. The molt progresses slowly at this stage with a single primary flight feather of each wing being replaced gradually over a period of several weeks until after the fourth primary flight feather is dropped. At this time the secondary flight feathers start to molt.

Captive Gouldian finches carry between nine and 10 primary flight feathers. They follow the same molt sequence as for wild populations with the first four primary flight feathers of each wing being replaced one at a time and in sequence. The main wing molt period begins in August following the re-growth of the fourth primary flight feather on each wing and ends late October. Normally, during this time each primary and a corresponding secondary flight feather of each wing are replaced in sequence and one at a time. The body molt is less critical for survival than the wing molt and is heaviest during September and October. The head feathers are the last to be replaced. These are molted during the last weeks of November and first week of December. Sometimes pinfeathers appear on the head.

The speed of the molt may accelerate or slow down at any stage in captive Gouldian finches. It is the primary flight feathers that best reveal a change in pace of the molt. The start time of the molt in captive flocks exposed to natural sunlight conditions may vary slightly according to geographical location and local weather conditions. However, under ideal conditions, captive Gouldian finches in Australia start to molt their primary flight feathers in July. February is the equivalent month in the Northern Hemisphere.

This initial stage of the molt often goes unnoticed as the four proximal primary flight feathers are replaced one at a time. The replacement of these four feathers is gradual and takes over a month to complete. Consequently there is no undue energetic or nutritional burden on the bird and physiological stress is minimized. However, the early progress of the molt may be retarded by poor nutrition, disease, breeding activity or cold winter weather conditions that often persist throughout July and August in temperate parts of Australia and in New Zealand.

To avoid a delay in the progress of the starting phase of the molt, captive Gouldian finches should not be allowed to breed beyond June in the Southern Hemisphere. In the Northern Hemisphere all breeding activity should cease by January.

Most Australian Gouldian breeders and scientific researchers view September as the beginning time of the molt period. However, this is incorrect as the molt begins at least a month beforehand. Instead September is the time when the peak phase of the molt begins, being obvious to fanciers as many feathers appear on the floor of the aviary. At this time, both primary and secondary flights start being replaced and new feathers on the body of juveniles appear. This is a time of increasing physiological stress and vulnerability for the Gouldian finch, as there is a sudden increase in energetic and nutrient requirements.

When the molt is progressing as rapidly as possible, the wing molt is complete by mid-October. As with wild birds, there is variation with some individuals taking longer to complete their molt (Milton Lewis, 2001). Individuals born at the beginning of the breeding season start to replace their primary flight feathers within a month of fledging. This occasion also goes unnoticed by breeders, as the wing molt progresses very slowly and juvenile body color remains unchanged until August/September.

Under ideal conditions the molt of adult birds begins as early as July. By the first week of August three or four primary flight feathers have been replaced in both adult and juvenile birds. Juveniles bred early in the breeding season start the body molt (i.e. replace their body contour feathers) by the second week of August. Adult birds start to drop body contour feathers during the second half of August. Under normal conditions, each primary flight feather is replaced one at a time in an orderly sequence starting from the innermost (proximal) and ending with the outermost (most distal) primary flight feather. The body feathers and secondary flight feathers start to molt when the fourth primary flight has been replaced.

This marks the beginning of the peak period for the wing molt that continues throughout September and into October. Sometimes two or more adjacent new primary flight feathers may be seen growing simultaneously during the peak period of the molt. All wing flight feathers are replaced by mid-October. The head feathers start to be replaced toward the end of the wing molt. The molt is concluded during the first weeks of December.

Variable Molt Speed

The progress of the Gouldian molt may be accelerated, delayed or completely halted. Molt abnormalities are most noticeable in captive birds toward the end of the molt when head feather abnormalities appear. These feather problems indicate a delayed molt, which may be created by poor nutrition, disease, poor housing conditions during the period of the molt. Stress induced airsac mite infection and other diseases will also delay the molt. The presence of a compressed molt indicates an accelerating molt. Baldness is the most obvious sign of a cessation of the molt.

Compressed Molt

From my observations, captive Gouldian finches are capable of growing multiple primary flight feathers simultaneously. The goldfinch *(Carduelis tristis)* shares this ability (Middleton 1977). This molt pattern is known as a compressed molt (Storer & Jehl 1985). A

Above left, this photo shows the head molt is almost complete in this healthy orange headed cock. Above right, a prolonged head molt with evidence of baldness is an indication of an abnormal molt, the cause of which should be investigated.

compressed molt is the visible evidence of an accelerating molt.

Theoretically a compressed molt in captive Gouldian finches may occur at any stage of the molt but mostly involves the fourth to 10th primary flight feathers. Sometimes it is seen at the end of the molt period when many pin-feathers appear together on the head. It is necessary to examine the flight feathers in order to differentiate a delayed molt from a compressed head molt.

There are a number of reasons why a compressed molt may occur. A compressed molt occurs most frequently during the peak period of the molt (September–October in Australia and March–April in USA). A compressed molt is more likely to occur when there has been a delay at some stage of the molt period. As well, healthy strong individual birds may have compressed molt, which in Australia may allow them to complete their wing molt by mid-October.

A compressed intense molt of some seabirds is believed to be an adaptation for exploiting an abundant food source (Storer & Jehl 1985). In Gouldian finches a compressed molt occurs only when plentiful food resources are available as there is a great energetic cost for flight feather growth (Guillemette 2007, Murphy M.E. 1996) with daily energy expenditure increasing up to 20 percent during the peak period of the molt (Jenni & Winkler 1994). Protein requirements are also increased during the molt as feather mass makes up 20 percent of total body protein (Murphy, King et al. 1988).

Consequently a compressed molt will not occur when food resources are low or of poor nutritional quality. A compressed molt should be considered a natural and healthy event for Gouldian finches and occurs in nature as a compensatory mechanism to ensure that the wing molt is completed as rapidly as possible.

Theoretically, conditions for a compressed molt in wild Gouldians occur when premature rains falling in September break a drought and quickly provide a bountiful supply of the annual and nutrient rich Fire Grass, the seeds of which are highly nutritious and favored by the Gouldian. A compressed molt may also appear following a drought period when heavy rains fall in early October and initiate rapid tussock growth of Cockatoo Grass that produces a very large nutritious seed also relished by Gouldian finches.

Delayed or Interrupted Molt

Prolonged cold winter temperatures or exposure to cold spells at the beginning the molt period coupled with an inadequate diet are the most common causes of a delay in the start of the molt in captive birds. For captive finches, a molt may be delayed by an extremely poor level of nutrition or by overlapping stress factors that may stop the molt completely. If this is to occur it will be seen after the first four primary flights have been replaced. Baldness is a sign that the molt has ceased completely. Hot or fluctuating temperatures during the peak molt period may also interrupt the progress of a molt. A compressed molt often follows a few weeks later as the stress from the hot period wanes.

Theoretically, physiological stress associated with the growth of the flight feathers in wild Gouldians may start as early as August and continue until late October at the close of the wing molt (Milton Lewis, 2001). During this time seed resources are declining and by late September and early October may be at their lowest level. Often when there is drought, food supply may abruptly decline (Crowley and Garnett 1994) around this time and delay the progress of the molt. Food supply must be plentiful during September or early October if a compressed wing molt is to occur in wild birds.

Molt, Immunity and Disease

In my experience, airsac mite and streptococcus infections are the most common stress induced diseases of captive Gouldian finches. In wild birds, these infections become life threatening when there are overlapping stress factors. This circumstance exists during drought when food resources are restricted during their molt. By delaying (slowing down) the molt, wild birds may reduce the level of stress and limit disease likelihood. Under these circumstances infection is unlikely to cause catastrophic losses because a sudden increase in airsac mite numbers is unlikely to occur. However, catastrophic losses are possible when there is a sudden interruption of a compressed molt. Red-headed birds are more susceptible to catastrophic losses from airsac mite or streptococcus infection as their immunity is already compromised by high testosterone levels and the molt process itself.

In nature, a compressed molt is likely to occur when rain follows a dry period that has delayed the onset of the main wing molt. The main wing molt is the simultaneous growth of the primary and secondary flight feathers that starts in August. The sudden availability of a rich food resource following rain promotes a compressed molt. If the Gouldian finch experiences an abrupt decline in the food supply, a high level of physiological stress will interrupt the compressed molt. Food supplies abruptly decline when there's no rain in early September to produce fire grass. Likewise if the October downpours do not occur to germinate Cockatoo grasses. A compressed molt is interrupted at this time because the life cycle of these grasses is very short-lived and seed availability sharply declines.

Molt, Immunity and Airsac Mite Infections

Sparrow studies reveal an increased energetic cost and a reduced immune response during a molt (Martin L.B., A. Scheuerlein, and M. Wikelski. 2003). Lowered immune responses were seen in sparrows during the heaviest part of their molt and greatest loss of immune function occurred immediately at the conclusion of the molt (Martin L.B., A. Scheuerlein, and M. Wikelski. 2003).

A critical reduction in immunity is to be expected when a sudden decline in food availability occurs during the height or at the conclusion of the molt (Franklin et al. 1998). This statement is even more relevant when there is a sudden decline of food during a compressed molt.

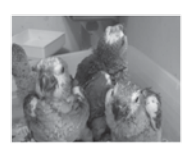
Airsac mite and streptococcus infections are common in captive Gouldian finches during the peak period of the molt in September–October in Australia and April–May in the U.S. Another peak period occurs at the conclusion of the molt in November–December in Australia and June–July in the U.S. Airsac mite infections during these months are often due to poor nutrition or fluctuating weather conditions. Fortified nutrition and repeat airsac mite treatments will prevent infections at these vulnerable times and help complete a timely molt.

Airsac mites are found naturally in the Gouldian finch *(E. gouldiae)* and co-occurring species: long-tailed finches *(Poephila acuticauda)*, Masked Finches *(P. personata)*, Pictorella Manikins *(Heteromunia pectoralis)*, Zebra Finches *(Taeniopygia guttata)*, Double-barred Finches *(T. bichenovii)* and Budgerigars *(Melopsittacus undulatus)*. The prevalence and intensity of infection in Gouldian finches is significantly higher than in other species except Pictorella Manikins (P.J.Bell 1996).

In the face of continuous threats from parasites, hosts have evolved an elaborate series of preventative and controlling measures—the immune system—in order to reduce the fitness costs of parasitism However, these measures do have associated costs (Sheldon B.C. and S. Verhulst 1996). In Gouldian finches, infections are capable of causing respiratory problems that can lead to death (Bell 1996; Tidemann et al. 1992c, 1993).

A symbiotic relationship between Gouldian finches and the airsac mite *(Sternostoma tracheacolum)* is likely to exist, as this endoparasite is present in a high proportion of the wild population (Tidemann et al. 1992c, 1993). In captive Gouldian finches, airsac mite infection is a common cause of illness and death. Infections cause illness in captive birds that then interrupt their molt. Signs of infection may not be obvious in many birds other than the effect it has on the progress of the molt. Infection delays the molt, the signs of which—mostly baldness—do not become apparent until the end of the molt when immunity is at its lowest ebb.

Acute infections often result in death as airsac mite numbers can rapidly increase within a short time. Persistent infection often results in death from secondary infections. Death from airsac mite infection is a rare event when adequate nutrition is provided during a normal molt i.e. when flight feathers are being replaced one at a time. However, diets fed to captive Gouldian finches during the molt are often inadequate, which predisposes them to sub clinical airsac mite infection, the signs of which are non-specific (i.e. fluffed up look, inactivity, ill-thrift and a delayed molt). Acute illness and death associated with airsac mite infections are most common when a delayed or compressed molt is interrupted by adverse weather conditions. Immunoprotection during part of the life cycle of the airsac mite Sternostoma tracheacolum helps explain the symbiotic relationship. Transmission of infection between Gouldian finches is by non-gravid non-gorged



female mites that mainly inhabit the upper respiratory tract, buccal (inside cheek) and nasal cavity. These female mites may also move to the posterior abdominal airsac, where they are protected from the host's immune response (P.J. Bell 1996).

Disease caused by a sudden increase in gravid female mite numbers is controlled by conditions that maintain a healthy immune system in the host. Non-gravid non-engorged female mites residing in the posterior airsacs are being protected from any immune response. These mites remain a potential source of rapid re-infestation should immunosuppression occur. When immunity is compromised—by social aggression or when a compressed molt is suddenly interrupted—a rapid increase in gravid female mites can occur because unfertilized mite eggs in the lungs are capable of arrhenotokous parthogenesis (i.e. unfertilized eggs capable of developing into haploid males) and proportionally more male mites persist in the lungs with small infra-populations (*Experimental and Applied Acarology* 1996).

Gravid female mites tend to occupy the airsacs, syrinx and trachea and move to the lungs to lay their eggs. This form of the mite is most responsible for the sudden onset of severe respiratory symptoms that will end in death. The eggs quickly hatch with the nymphs and sub-adults feeding off the blood rich pulmonary tissue. This stage of infection causes asthmatic type symptoms leading to an inability to fly and disinterest in foraging. Adult male mites remain mostly in the lungs. The life cycle may be completed within six days (P.J.Bell 1996) so that many birds can become infected and die over a very short period of time.

The consequence of airsac mite infections is rapid and severe because infra-populations may dramatically increase in size within a very short period of time. Infections decrease appetite and mobility and become rapidly life threatening because finches must eat and drink each day. The ability of airsac mites to complete their life cycle rapidly under certain conditions and produce many mites renders Gouldian finches extremely vulnerable during times of acute stress.

Gouldian finches, especially juveniles are thought to become vulnerable at the closing stages of the molt when the nutritional resources needed to support the molt are lacking. In nature, Gouldian finches are most vulnerable at the end of the molt period when food resources are low or abruptly decline at this time. The high prevalence of airsac mite infection seen in captive Gouldian finches at this time supports the view that airsac mite infections are a result of a depressed immune response.

Catastrophic losses are possible as a result of infection because airsac mite numbers can rapidly explode when the immune response is severely compromised. Losses are likely to occur as a result of airsac mite infection at the conclusion of the molt in November and when a compressed molt is interrupted by a sudden decline in available food resources during October.

Acute physiological stress during the molt period is most likely to occur when a compressed molt is interrupted, when a delayed molt is compromised by cold weather or poor nutrition toward the end of the molt period. Acute airsac mite infection of red-headed individuals is also possible when they exhibit social aggression at the beginning of the breeding season.

Management of Wild Populations

The Gouldian finch is now considered rare in Western Australia and endangered in both Queensland and the Northern Territory (Tidemann et al., 1999; O'Malley, 2006). In 2000, wild population numbers were predicted at 2500 breeding birds, with a downward trend evident (Gelis, 2003). To conserve the wild Gouldian finch populations and save the species from endangerment, management strategies must be implemented and recovery programs realized.

The most significant action taken to improve the current status of the Gouldian finch has been the development of a National Recovery Plan (O'Malley, 2006). This was initiated in 1994 in collaboration with the National Gouldian finch Recovery Team, as a guide into research of the diet, reproductive biology, population dynamics and potential threats of the finch (O'Malley, 2005). The plan outlines actions such as land management, taking into account the impact of fire and grazing on the finch population, restoration of habitat and reintroduction into the wild (O'Malley, 2005; Soucek, 2008).

Land management has important conservational implications with regards to the Gouldian finch (O'Malley, 2006). Although precise habitat requirements are still unclear, persistence of populations of the Gouldian finch at certain sites enables recognition of critical elements contributing to the success of such populations (Dostine et al., 2001). A number of landscape components appear to be important for the survival of Gouldian finches. Large areas of rocky hills with a dense understory of sorghum grasses characterize the finches' breeding habitat during the dry season (O'Malley, 2006; Soucek, 2008). The topography of these sites, in addition to natural barriers such as rivers and creeks, restricts the spread of fire, reducing its impact on seed availability (Dostine et al., 2001). Presence of large numbers of gum trees in these areas, favorably salmon gums or northern white gums, is also important in providing nesting hollows for the finches (Dostine et al., 2001). Gouldians need to drink every day, hence reliable water sources are essential, preferably in the form of shallow waterholes protected from predators (O'Malley, 2006). Patches of grassy woodlands within 10 kilometers of the Gouldian finch breeding grounds in the lowlands provide a food source in times of seed shortage, such as throughout the wet season (Dostine et al., 2001). In habitat management, preservation of these areas of woodland is critical to ensure the finches have access to alternate feeding sources at times of food shortages that may occur toward the end of the dry season (Dostine et al., 2001; O'Malley, 2006).

Identification and preservation of key habitat areas is critical to conservation of the species (Dostine et al., 2001). Monitoring of population trends and analysis of health in different finch populations is an essential in assessing the success of any management regime (Dostine et al., 2001; O'Malley, 2006). Knowledge of the landscape is also important in developing appropriate fire and grazing management strategies in major Gouldian habitat sites (Dostine et al., 2001; O'Malley, 2005). Finally, realizing aspects of the habitat that contribute to the persistence of Gouldian finch populations in these areas could also assist in strategizing the reintroduction of additional populations into carefully managed habitats (O'Malley 2005).

As described earlier, fire and grazing processes are significant threats to the long-term survival of the Gouldian. Current management regimes regarding these two issues are being implemented at sites where significant Gouldian finch populations have been identified in an effort to preserve the crucial habitat required by the finch for survival (O'Malley, 2006). Manipulating the distribution and timing of fire has also been described as a way of encouraging seed growth of the key wet season grasses, but also protecting nest trees and feeding areas from the detrimental effects of large, hot fires (Dostine et al., 2001; O'Malley, 2005). Fire management is based on forming mosaic patterns of burnt and unburnt patches of land, with the intervals between each burning varying (O'Malley, 2005). This mimics traditional practices carried out by Aboriginal people, prior to European settlement (O'Malley, 2006).

In terms of grazing management, fencing off important wet season grasses from production animals and feral pigs has been suggested to preserve feeding habitat (O'Malley, 2006). However, this could affect livestock productivity, thus cooperation with pastoral land managers may be difficult. Feral herbivore control is the current grazing management practice. These management regimes are still not ideal, so further progress needs to be made with regards to current knowledge on habitat, diet and foraging behavior of the Gouldian finch, and the precise impact of inappropriate fire and grazing practices on the survival of the species (Dostine et al., 2001; O'Malley, 2006).

The availability of cockatoo grass during the wet season is thought to have a positive impact on breeding outcomes for wild populations. Landowners in regions inhabited by Gouldians could benefit financially by replacing grazing land for a commercial plot of Cockatoo grass and at the same time provide Gouldians with a reliable food supply during the wet season. Commercial production of Cockatoo grass is underway in northern Territory, the seeds of which are favored by Gouldian finches during the wet season.

Recently, the reintroduction of aviary-reared birds into protected habitats has been trialed as a conservation tool (O'Malley, 2005) in Mareeba, Queensland. Its success relies strongly on habitat enhancement, threat abatement in release areas, and continual monitoring of the reintroduced birds (O'Malley, 2006). Predation has hindered reintroduction efforts (Wildlife Conservancy of Tropical Queensland, 2009), and O'Malley (2005) describes plans for future trials where finches spend less time in captivity, in the notion that they will have retained predator avoidance behavior by the time of their release.

One final management strategy to be considered is community involvement and increasing public awareness. Members of the community can facilitate the monitoring of Gouldian populations by reporting sightings or participating in annual waterhole counts (O'Malley, 2005). Additionally, encouraging pastoralists and Aboriginal landowners to test fire management regimes on their properties would be of significant benefit to the Gouldian recovery effort (O'Malley, 2006). Although this would involve some economic cost to the landholders, productivity losses would be reduced due to improved fire practices thus limiting large, hot wildfires that destroy property and pasture resources (O'Malley, 2006). The Jawoyn Aboriginal Corporation is actively involved in the recovery effort, participating in fire management and feral herbivore control on Jawoyn lands with significant Gouldian finch populations. It is in the interest of the recovery team to increase the involvement of the Aboriginal community, as the finch distribution covers much of their land (O'Malley, 2006).

There have been three successive recovery plans for this species (O'Malley, 2006). The current program runs from 2007 to 2011, with an estimated cost of $970,000. This is being met by State and Territory governments, numerous organizations, including Aboriginal, pastoral and conservational groups, and the general public. However, it is likely that costs will continue past the length of the plan, as the recovery process of the finch is anticipated to exceed five years (O'Malley, 2006).

For the conservational status of the Gouldian to be changed, populations will need to show a sustained increase in numbers over several seasons (O'Malley, 2006). By adopting the management practices described above, such a goal may be achieved.

Management in Captive Birds

Good management of captive flocks during the molt should be a priority for all Gouldian breeders because a rapid molt is a sign that breeding outcomes will be good. Above all, a balanced diet fortified with protein and energy is required by Gouldian finches to rapidly complete their molt. In addition repeat treatments against airsac mites will ensure a rapid molt. Preparations for a good breeding season must begin early (the beginning of August for the Southern Hemisphere and Feb. 1 for the Northern Hemisphere) to ensure the molt is completed as rapidly as possible.

Every effort must be taken to support a rapid molt, because there is a strong relationship between the completion of a rapid molt, good health and a successful breeding season. When receiving the best care, the molt of Gouldian finches will be completed in November (Southern Hemisphere) and May (Northern Hemisphere). Breeding may then commence by Christmas (Southern Hemisphere) and June 25 (Northern Hemisphere). The accompanying Molt and Breeding Programs will give your birds the opportunity to enjoy a rapid molt and two highly successful breeding rounds before June (Southern Hemisphere) and December (Northern Hemisphere).

Airsac mite infections are inherent to wild Gouldian finch populations and it should be assumed airsac mites are present in all captive Gouldians. Infection exists in a dormant state when ideal conditions create good health. Any stressful episode will activate infection. In captivity, stressful conditions occur during the molt, breeding and in juvenile birds.

Cold spells at the start of the molt may delay the molt and create a compressed molt. During a compressed molt multiple flight feathers grow simultaneously. Ivermectin treatments administered for two consecutive days each three weeks must be given during a compressed molt because Gouldian finches become vulnerable to airsac mite infections at this time even when they receive good nutrition. Airsac mite treatments must be given regularly during the molt and breeding seasons in order to prevent infection during these naturally stressful periods. Gouldians are particularly vulnerable to infection at the end of the molt and at the beginning of breeding when their immunity is at its lowest ebb.

Poor breeding results are likely when treatments are not regularly administered as Gouldians infected with airsac mites succumb to chlamydia *(Ornithosis)* and streptococcus infections. Airsac mites become a problem when Gouldians experience stress, and especially when additional stress factors such as changing weather conditions (e.g. warm weather followed by sudden cold and wet spells) occur during the molt. The immediate effect of airsac mites is to retard the molt, so that often birds with baldness are suffering from airsac mites and respond quickly when treated with Ivermectin or Moxidectin each week for three weeks. Airsac mite infection starts a vicious cycle that interrupts and delays the normal molt cycle. The end result is a prolonged molt, weakened bird, infertility, parental neglect, rejection of the babies, parental deaths and poor breeding outcomes.

The Gouldian molt may be normal, compressed or delayed. Normal and compressed molts occur in well-managed aviaries. A delayed molt (e.g. head baldness, pin feathers on head) indicates a failure to provide good nutrition, airsac mite prevention or a protected aviary environment. It is during the peak molt period in October and immediately following the conclusion of the molt in late November or early December, that most molt-related health problems appear. Bird deaths and catastrophic outbreaks of airsac mite infections are likely during these times especially when a cold spell interrupts a compressed molt.

References available upon request from AFAWatchbird@afabirds.org

AFA CORPORATE SPONSORSHIP PACKAGES

AFA SPONSOR

Platinum Sponsor $10,000 plus:

- *Use of AFA logo "An official sponsor of the American Federation of Aviculture"*
- *Four (4) full page color ads in Watchbird*
- *One (1) complimentary booth at AFA convention, nontransferable*
- *Convention signage "Visit our Platinum Corporate Sponsor" (includes sponsor name and booth number)*
- *Two convention registrations*
- *Recognition at convention banquet*
- *Corporate sponsor plaque*
- *Recognition in Watchbird, on AFA website and convention program/proceedings*
- *Individual AFA membership*

AFA SPONSOR

Gold Sponsor $5,000 plus:

- *Four (4) one-half (1/2) page color ads in Watchbird*
- *One (1) complimentary booth at AFA convention, nontransferable*
- *Convention signage "Visit our Gold Corporate Sponsor" (includes sponsor name and booth number)*
- *One convention registration*
- *Recognition at convention banquet*
- *Corporate sponsor plaque*
- *Recognition in Watchbird, on AFA website and convention program/proceedings*
- *Individual AFA membership*
- *Four copies of each issue of Watchbird*

AFA SPONSOR

Silver Sponsor $2,500 plus:

- *Four (4) one-quarter (1/4) page color ads in Watchbird*
- *Discounted booth at AFA convention, nontransferable*
- *Convention signage "Visit our Silver Corporate Sponsor" (includes sponsor name and booth number)*
- *Recognition at convention banquet*
- *Corporate sponsor plaque*
- *Recognition in Watchbird, on AFA website and convention program/proceedings*
- *Individual AFA membership*
- *Two copies of each issue of Watchbird*

AFA SPONSOR

Bronze Sponsor $1,000 plus:

Become an AFA Corporate Sponsor Today!

P.O. Box 91717 • Austin, TX 78709-1717
Phone: (512) 585-9800 • Fax: (512) 858-7029
www.AFABirds.org

AMERICAN FEDERATION OF AVICULTURE INC.