Effect of Controlled Lighting on Band-tailed Pigeon (*Patagioenas fasciata*) Breeding

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Significance

De-extinction of the passenger pigeon (*Ectopistes migratorius*) will require editing the genome of the extinct species' living relative, the band-tailed pigeon (*Patagioenas fasciata*)[1]. This process will involve the isolation, engineering, and transfer of primordial germ cells to produce germ-line chimeras, which will subsequently be bred to generate progeny carrying passenger pigeon genes. The development of culture conditions for avian primordial germ cells and germ line transfers demands reliable acquisition of viable embryos. This emphasizes the need for a captive flock in which fertile embryos can be procured regularly and consistently. Such a flock would be invaluable to band-tailed pigeon (BTP) research and management, especially given recent declining trends in BTP populations over the past 50 years[2]. This decline has been attributed to improper game management[3], but more recent declines are associated with trichomonosis pathogen outbreaks, which cause thousands of deaths[4]. A captive flock establishes a major resource for controlled infection experiments and the development of treatments. The ability to adequately propagate BTP's in captivity will also ensure the long-term survival of the species.

Background

Band-tailed pigeons are seasonal breeders in the northwestern California, Oregon, Washington, and southwestern British Columbia. Young are produced from eggs laid in late March or early April from a single egg that is incubated by both parents [5]. Squabs are cared for by both parents. Weaning takes place at about five weeks of age. Most frequently only one squab is raised each season which ends in early September[5,6]. Band-tailed pigeons are capable of raising multiple broods in a single breeding season. If a second brood is attempted the egg is usually laid around the summer solstice; Rarer third nestings have been observed starting in Late July to September. [6] .

While there has been extensive observation of natural breeding cycles of wild band-tailed pigeons, observations of the birds in captivity have seldom been published. The only reference to manipulating egg cycles dates to 1916, when the first egg of a breeding pair of BTP's laid in a pre-constructed nest was removed the adults "began to build a [new] nest immediately" and soon after a new egg was laid[7]. The first egg was transferred to a pair of rock pigeons (*Columba livia*) for surrogate incubation. The rock pigeons continued to raise the BTP squab after hatching. This observation was unable to provide an estimate for the number of days between egg lays.

The use of controlled lighting (photoperiod) to stimulate breeding and egg production has not been attempted with this species. Manipulating photoperiod is a proven method in the poultry industry to stimulate egg production[8] and has stimulated breeding out of season experimentally in many species (e.g. dark-eyed juncos, zebra finches, various sparrow species, Japanese quail[9], and American kestrels[10]). Based upon results with other avian species our a priori expectations were that BTP's would respond to controlled photoperiodicity positively and that continual breeding and fertile egg production could be induced and maintained.

Pilot Study

The purpose of this initial study was to determine if exposing BTP's to a constant 15.5 hours of daylight beginning in late November would cause the hens to begin laying before onset of the normal laying season and to determine the maximum laying cycle achievable with this species. When eggs were laid they were removed from the nest to stimulate egg replacement. Several eggs were transferred to rock pigeon pairs for incubation.

Two pairs of BTP's were obtained from Exotic Wings International, where breeder Sal Alvarez manages a captive flock. The BTP's were housed in an 8' x 15' building that has an east-west orientation. Nests were provided at 60" above floor level and consisted of a platform measuring 13" x 13" x 2".

Observations

Prior to the study the birds were housed in a loft that had only natural lighting. They arrived on November 14, 2014 and had therefore been experiencing declining length of day since June 21st. All birds were experienced breeders and had been housed previously in the same loft although they were not mated to each other. Upon release they were extremely nervous and the decision was made to release and then leave the building. Each day thereafter the same caretaker entered the building in the morning, moved around slowly while talking in a soft voice and took care of daily feed/water issues after which he immediately left the building. Thus, the birds were alone for 23 hours and 50 minutes each day, on average. This isolation was intended to minimize stress during acclimation.

Over the course of the next two weeks the birds became more accepting of the caretaker. In the beginning they would move to the far end of the building and would attempt to fly out of the building towards external light. By the end of two weeks they had settled down and did not attempt to flee but still traveled in the rafters to the far end of wherever the caretaker was working. For the duration of the experiment the birds never became "tame", only tolerant of the caretaker. Periods of panic would ensue for no apparent reason for the first two months after which random flightiness subsided.

The pairs were monitored remotely by video camera for observations while the caretaker was not present. Initially the pairs were allowed to breed and live communally, but when nest building began territorial disputes between the males increased in frequency. Such disputes endanger eggs during incubation. Though eggs were removed after laying, the risk of confrontation causing damage existed in the short period of time between laying and detection of the egg. The pairs were separated by a netting barrier to prevent territorial issues escalating into aggressive confrontations separated the pairs.

Photoperiod

Lighting was provided by two 4' florescent bulbs controlled by a light clock set to turn the lights on and off twice each day. The first lighting period commenced at 4:30am and ended at 7:30am. The second lighting period began at 4:30pm and ended at 7:45pm. This program ensured that the birds would receive consistent uninterrupted light exposure from 4:30am until 7:45pm. All times are based on standard daylight time. Total lumens at floor level were 4.5. There were no shadows created by the lights. Lengthening daylight triggers breeding; conversely, shortening day length takes birds out of production[9]. Our study daylight exposure time set equal to the daylight duration of the summer solstice at the latitude of the housing unit. Since the housing unit allows natural daylight to penetrate any shorter photoperiod regime would have allowed a minor lengthening of daylight during the summer solstice, which would have been followed by day length shortening, triggering cessation of breeding; even minor fluctuations in day length can effect breeding cycles.

Diet

Feed was provided ad-libitum and was a standard pigeon diet based on whole grains. This mixture was supplemented with Zupreem® fruit blend pellets formulated for “exotic” pet birds. Municipally supplied and chlorinated tap water was provided ad-libitum. Feed and water were checked daily as was the integrity of the house and condition of the birds. Birds were never handled to prevent unnecessary stress, which may have negative impacts on egg production.

Results and Discussion

The controlled photoperiod induced breeding courtships for both pairs in late December, 2014. Hen #1 laid her first egg on January 30th, 2015. Hen #2 laid her first egg on February, 10th, 2015. These dates precede the natural breeding cycle of these birds (observed in previous years by former keeper Sal Alvarez) by nearly 2 months. A total of six eggs were laid by the two hens over the course of the study. Both Hens laid 3 eggs each continuously for a period of several weeks when egg production was interrupted by stress induced by the appearance of a Hawk, taking the Hens out of production. While objects outside the housing are not clearly visible, the shadow silhouette of the Hawk was enough to cause panic. Hen #1 resumed egg laying in April, 2014.

Table 1. Time between egg lays for BTP hens.

	Hen #1	Hen #2
Time between eggs 1 &2	14 days	8 days
Time between eggs 2&3	8 days	12 days
Time between eggs 4&5	9 days	-
Time between eggs 5&6	10 days	-

The time between egg lays ranged from 8-14 days, averaging 10.2 days. More trials will be necessary to provide statistical significance, but we feel estimating 10 days between eggs for BTP’s is reliable for future work with the species.

Mating behavior, copulation and nest building appeared to be normal for both pairs. When eggs were incubated by the BTP’s, the males shared in incubation from late morning until early afternoon as has been observed by naturally breeding pairs. All eggs were fertile and all embryos whether they hatched or were taken prior to hatching showed normal positioning of the embryos. Shell debris showed no abnormal bleeding and shell residue was normal indicating that hatchings proceeded without incident.

Six of the eggs were incubated under surrogate parents, rock pigeons that are located on the same premises as where the lighting experiment was conducted. The rock pigeons showed no curiosity about the eggs and they were accepted and were incubated with no issues.

No squabs were raised from the six eggs so there is no data from grow-out from which to compare progeny performance. One fertile egg left to be incubated by BTP’s was abandoned. One embryo hatched, but shortly after fell from the nest and was found dead. No embryos incubated by rock pigeons survived past hatching. One egg was damaged before it was transferred to rock pigeons and development was arrested, but the egg was incubated. One embryo initially incubated by rock pigeons was abandoned shortly before hatching. One egg was unaccountable after successful incubation for nearly two weeks; no remains of the egg were detected. The rock pigeon aviary, though protected by several perimeter barriers is not absolutely impenetrable. It is possible a snake breached the aviary and consumed the egg. One egg was damaged by the rock pigeon incubating it. The final egg was moved to a laboratory facility for automated incubation. This embryo was terminated prior to hatching to isolate tissues for studying BTP genetics.

Optimization

The goal of working with any species in captivity should be to provide sufficient conditions to ensure optimal behavioral and physical health. We've demonstrated that continual egg production is possible without adverse behavioral of physical effects. In order to eliminate other risks to health of both breeding birds and progeny, pairs should be kept separated to avoid confrontation. Separation will also allow breeders to maintain breeding pedigrees, as many pigeons and doves have been observed to be promiscuous in communal settings. To prevent stress from external factors (such as birds of prey or sound disturbances) lightproof breeding facilities should be used and furbished to dampen sound. Special care for ventilation and protocols for working with birds should be designed to prevent the invasion of pathogens. Considering the flightiness of this species we recommend remote monitoring and gradual acclimation to new environments and handlers. Nest platforms are preferred to nest boxes, and the species prefers nesting higher above ground, though it is likely that pairs will breed and live comfortably in smaller quarters than were provided in this study.

Conclusion

The experiment, although small in design showed that early controlled lighting of BTPs can induce continual egg production well in advance of the normal seasonal time period. With an average of 10 days between fertile eggs, it may be possible to produce 50 embryos per year from a single breeding. With optimized housing conditions and proven surrogate rock pigeon parents a small flock of BTPs can propagate significantly larger numbers of offspring than an equivalent natural BTP flock. It should be possible, also, to increase squab survival in a captive setting.

References

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