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No. 1 Tropical Bird

Most of the visitors to Nectandra Cloud Forest Garden are first time travelers to Costa Rica, interested in getting their first cloud forest experience. The entrance of the garden is directly on a national highway, fronted by a very tall, wide gate that screens off the garden proper. For all, driving through that gate is a startling experience. One minute on a paved highway, the next completely enveloped by a thick canopy of old forest with dangling vines, thick epiphytes, moss and liverworts, all of it shrouded in a thick mist. After a short adjustment to the cool and revitalizing fresh air, the visitors become aware of the overwhelming variety of green shapes. They begin to hear the drip-drip of the mist, and the birds. It is difficult for them to delineate individual plants among all this greenery. Here, trees grow on trees that grow on other trees. One of the great pleasure for the guides during their hikes is the chance to point out all the unfamiliar, as well as the "hidden" familiar in the jumble. After a short spell of this, we like to take them through the trails and up to the fence line with our neighbor. On one side of the fence is the magnificent forest, on the other, pure African grass since ten years ago when the neighbor had cleared his land for cattle. This stark contrast invariably prompts the viewers to ask, "How fast does it regenerate?".

Nectandra Preserve is about to inaugurate a new garden named Persea, located immediately across the road from the Nectandra Garden. Whereas Nectandra is edge-to-edge mature forest, Persea began as a conservation property only 5 years ago, when it was smothered by 6 feet-tall exotic wild grass after the previous ornamental plantation owner ceased operation. The two gardens couldn't be more different even though they are only 50 feet apart. We thought our visitors might enjoy seeing the marked contrast.
With the two gardens side-by-side, they will have a chance to gauge for themselves just how fast native trees grow and to witness the biodiversity of natural succession *in situ*.

Persea came with a single large shed where the ornamental crops were cleaned and readied for export. Inside, cheesy magazine pages had been used as wallpaper, and an enormous mound of debris accumulated after years of neglect. After much thought and labor, we converted the wide open shed into a small exhibit hall and a reception center for our Persea visitors. The space will house audio-visual displays on topics related to cloud forest and the natural history of tropical fauna and flora. It is too small for general displays, but large enough to have educational exhibits on focused subjects. Birds and leafcutter ants are the most visible fauna at Persea, so they will be the logical themes for our first exhibits The plan was to use pointed exhibits to highlight the biology and natural history of ants and birds in the limited physical space. Specific facets of the two subjects will be used to intrigue and to inform.

The tropical leaf cutter ants are less familiar to most North American visitors (except those from the southernmost 4 states where leafcutter ants are residents). They have fascinating life styles, so almost any information about them would be new and exotic. (A brief summary of leafcutter ant literature appeared in last year's newletter).

The birds, however, were a bigger challenge. There are millions of avid birders in the world with in-depth knowledge of birds. A lot of searching and homework are necessary to find clever angles to capture the sophisticated viewer's attention.

I made a short list of bird features that I knew little about, starting with form and functions of bird feathers, beaks, wings, and ending with the phylogeny of birds. Article after journal article reported on the growing list of species with shrinking population. Instinctively I wanted to know if there were any species that are growing in population when next question popped into my mind, " Which is the most numerous tropical bird species today?" Why, chickens, of course.

For most of us, chickens are less a bird than meat on the table. We humans consume annually enough meat and eggs (65 million metric tons) to require 50 billion chickens! In the US, the per capita consumption is 80 pounds of chicken meat per year. China, USA, Indonesia and Brazil are the top four poultry producers. Intensive modern poultry farming calls for ultra high density chicken sheds, e.g, 20,000 broilers (for meat) or 150,000 egg layers in each chicken house. This grand scale of production comes with its concomitant problems — concentrated waste, air pollution and pathogens for both the birds and people.

I grew up with a small flock of chickens in our immense garden, so I had some general knowledge of their biology. I knew they were omnivores, often destroying the flower beds with the constant soil scratching and pecking for seeds, insects and worms. They lived 2-10 years and were sexually dimorphic. The roosters had brighter, more colorful and more elaborate plumage than the hens, as well as more prominent cockscomb and waddle. They ran around the yard in flocks, some more domineering than others, thus had a "pecking order". Flightless, they were helpless against weasels, snakes and other wild carnivores. We lost many to predation over the years. The hens laid clutches of 10-12 eggs in their favorite locations, after which she would incubate them continuously until the fertilized eggs hatched (I would steal them at this stage). If not, she would eventually abandon them. Today the eggs sold commercially for food are unfertilized eggs. Fertilized eggs are produced only for breeding, for use in biomedical research and for vaccine production. Nearly every part of the chicken is edible. I chuckle every time I remember the occasion when my aunt schemed and served as entrée a huge platter of stewed, whole chicken feet to discourage a guest (her daughter's suitor), who had never been exposed to chicken parts in his diet.

I also knew, from plucking and dressing many killed chickens during childhood, that there were at least three varieties because the skin came in three colors: white, yellow and black. The different number of toes in these chickens also intrigued me. The black chickens had 5 toes, whereas the other two had only four. My mother would prepare different chickens for different occasions and dishes. For honored guests, the yellow skinned, for lesser diners the white-skinned, for the sick or pregnant the black fleshed. Interestingly, the black-flesh chicken had feathers that were silky, fluffy and pure white, but the bones, organs (yes, even the testes) and feet were ink-black (Fig 1). To a child, the three skin colors were completely normal. Humans came in the same three colors, why not chickens? Yet, I couldn't come up with an explanation that the different number of toes.

Fig.1 Chickens in Asian markets

I now know that there are many hundreds of chicken breeds, whose pedigrees are carefully documented and governed by societies of poultry fanciers all over the world. Chickens are bred for more than just increased quantity of meat and eggs, but also for an astounding number of other characteristics. They are selected for unusual feathers, egg colors, temperament as pets and brooders, for their prowess as cock fighters, molting patterns, plus an astounding list of characteristics. For example, the black-fleshed chicken mentioned above, an ancient Chinese breed named Silky (for their feathers), is today bred for additional variations in their fluffy body feathers that lack feather barbs, (a characteristic also of down feathers). Another example is the Japanese Onagadori breed, prized for their immensely long, beautiful tail feathers — the outcome of the recessive genetic mutation causing cessation of molting in the tail feathers, hence the accumulated length. (Fig.2). And lest we forget for aggressiveness and strength as fighting cocks. In fact, ancient domestication of the chickens began more for their fighting than for food.

Silky Onagadori Modern Gamecock

Fig2. Domesticated chicken breeds.

From very recent analyses of DNA sequences, detailed new information is slowly emerging on the ancestry of the modern domesticated chickens, *Gallus gallus domesticus*, In Darwin's time, there were two contending theories concerning the derivation of chickens. Basing on his cross-breeding experiments and close observation of character differences, he favored the one-ancestor over the multiregional (from multiple ancestral lines) theory, and concluded that the wild red jungle fowl *Gallus gallus*, a tropical bird in the Order Gallinae (fowls, quails grouses), is the most likely progenitor of the domesticated chicken. After a 150 years of debate, the latest molecular data confirmed that Darwin was largely correct, but not entirely.

Fig. 3 Wild red jungle fowl in SE Asia (left). Feral rooster on the island of Kaui (right). Note the similar white patches.

Chicken domestication began around 7000 years ago, later than the canines (> 32,000) and ruminants (9000). The oldest chickens bones (6000 yrs) were found in northern China, where it was too cold to be within the home range of the ancient tropical bird. Ground zero is much more likely to be in the Indus Valley (modern Pakistan), with subsequent migration radiating westward through the Middle East to Europe (thanks to the Romans) and eventually the Americas via the Spaniards. Eastward migration was through East Asia and then Polynesia. Today, the wild red jungle fowls still live and are found running free in India and many parts of South East Asia in reducing numbers. In appearance, the modern wild red jungle fowls and the modern feral chickens I saw running on the island of Kaui are strikingly similar (fig 3). In fact, hybridization between the wild fowl and the domesticated chickens is still occurring in nature— a source of wild species depletion.

In the modern laboratory, hybridizations between the red jungle fowl and various pedigreed chickens are being studied after the manner of Darwin's original cross breeding, but at the molecular level. These investigations are beginning to clarify the genetic "flow" from the wild to the domesticated versions. The same studies often yielded information on the geo-migration, as well as the molecular basis of various phenotypes in the chicken, including the skin colors I noted in my mother's kitchen.

It's long been known in poultry husbandry that the yellow and white skin colors (visible also on the legs) are associated with the amount of carotenoids (organic plant pigments) in the chicken feed. The color fades when carotenoids containing feed is withdrawn from the diet, but not to the same degree depending on the chicken breeds. It turns out that there is an enzyme in the skin cells that breaks down yellow carotenoids into colorless products. In the absence of this breakdown, the pigments accumulate and renders the skin yellow.

In the modern crossing experiments, the red jungle fowl (white skin) were crossed with white skin and yellow skin domesticated breeds. The progenies with white skin had two copies (one from each parent) of the genes that led to white skin. Those that had yellow skin had two copies of the yellow skin genes, whereas the chickens that inherited one white and one yellow copy had white skin, indicating that the gene regulating white skin is dominant whereas that for yellow is recessive. When the DNA sequences of the enzyme gene were compared, the white genes in domesticated chickens were nearly identical to that of the red jungle fowl, but the sequences of the yellow skin gene did *not* come from the red jungle fowl, but most likely from the gray jungle fowl, whose wild modern counterpart exists only in India today.

What about the back skin Silky chicken? Turns out the genetic basis for the Silky's black skin is also exceptional. In vertebrates, the precursors of cells (melanoblasts) that produce the dark pigment melanin migrate from its embryonic origin to their final destination in cartilage, bone, smooth muscle and nervous tissues. In Silkies, the melanoblasts travel in an abnormal pattern to settle outside its normal target organs—to connective tissues and internal organs, causing the chicken to look black through and through. Although the studies are incomplete, it appears that the genetic basis for this dominant trait rests in a single mutation that is duplicated many times in the Silky, resulting in the hyperpigmentation in the melanin producing cells distributed over the body.

So once more, curiosity about one thing led to learning about many other things. I started with a seemingly simple question about one bird, and a whole new horizon opened up on learning about the results of modern approaches to studying an old friend the chicken. And most unexpectedly, my long ago misconception about chicken skin color is now dispelled once and for all. What about the toe number? Alas, the number of toes remains a mystery to be researched, but if I am patient , I may be awarded someday with an explanation and much more.

Audubon Christmas Bird Count at Nectandra Garden

Each December, Nectandra Garden participates and contributes to the Christmas Audubon Bird Count. We host 4-5 volunteers (plus one representative from Nectandra) for one day and one night while they count birds (diurnal and nocturnal) within our 350 acres property. In return, we benefit from the vital data they collect, not just on our property, but on 10 others within a "count circle" a circular area roughly 15 miles in diameter. Designed to study the wintering range of US species, the Christmas Bird Count expanded to 16 countries in the Western hemisphere since its inception 115 years ago.

As the conservator of our preserve, I await eagerly each year for the numbers generated by the Bird Count. I want to know where, what species visit our forest and, less reliably, how many birds were counted. Now that we have four years of participation, I am beginning to pay attention to the numbers accumulated and to consider what those numbers really tell us relative to bird conservation.

Numbers are tricky. They tell no lies yet do not tell the whole truth. For example, they tell us the number of species recognized (by sight or song) by the 5-6 individuals (different from year to year) on the designated route (the same from year to year) within each site. They also tell us the number of each species encountered in one direction along the route (to minimize counting the same bird multiple times). However, there are inestimable number of confounding factors that can affect the interpretation of the data and their analysis.

One single day, after all, is far too short an interval to make anything of the fluctuation in the annual bird and species density — a mere blink out of a winter season. This brief interval allows the local weather to have the most dominant effect on bird monitoring. For example 2014, at Nectandra, the day before and the day after the Bird Count were both mild and with good visibility. The weather on the day of the Count, unfortunately, was miserable. The volunteers had to slog in the forest under heavy rain, high wind and almost no visibility. The birds are difficult to spot among the heavy forest foliage even on sunny days, let alone during inclement weather and after dark. In other words, the low bird count was as much an indicator of how well the birders can see or hear as anything else. It would have been impossible to see even if the birds were present.

Then, there is the matter of geography. Costa Rica may be a small country, but its volcanic origin makes its land surface tremendously convoluted and thereby dominated by microclimates. For example, Nectandra Garden sits on a hillside at 1100m, fully exposed to gale force December Caribbean trade winds. In contrast the neighboring site just a few kilometers away is nestled in a valley at lower elevation. The weather there is often as dissimilar to Nectandra's as night and day. By comparison to Nectandra, they had an above average 2014 bird count.

There are a number of other limitations to the "point counting" approach. For example, what about the varying skill of the counters? Their different hearing and visual acuities? Even the very effort in bird counting is known to have an influence on the bird population being counted. Scientists are researching on methods to overcome these very same shortcoming in their analyses.

Despite these troublesome limitations, the Christmas Bird Count, encompassing 2300 count circles in 16 countries, is the only one monitoring of its kind, with broad enough range to give us the "big picture" of the distribution of wintering birds in the Western Hemisphere. It's 115 years old running record has given us the longest continuous bird monitoring data available. The statistical value of such longtitudinal monitoring is immense.

Other News Highlights 2014

**** Reported by Luis Villa ****

Jul 2014 Annual tree planting work by Nectandra Institute's partner communities continued this month. Overall this year, more than 3,500 trees have been planted in several different eco-loan financed restoration properties. Children from the upper Balsa River watershed community of San Luis also joined in the effort, planting several *Citharexylum donnell-smithii* seedlings on the property purchased in 2011 by the community's water management association.

Aug 2014 Nectandra Institute staff and local volunteer youths completed the semi-annual collection of aquatic insects from sampling points along streams and rivers in the upper Balsa River Watershed. Over 20 riparian locations are being monitored twice yearly for macroinvertebrates. Some of these organisms are known to be tolerant to organic-based pollution, while others not so much. Thus, we can learn about the water quality at each of the various sampling points by analyzing the mix of insects found in these river ecosystems.

Sept 2014 Nectandra Institute and its partners in the Balsa River Watershed celebrated the 7th annual New Culture of Water Month. This 30-day long festival is hosted by a different community each year with the goal of recognizing local efforts to protect water resources, conserve and restore forests, and maintain watershed health. This year's edition included popular holdover events from prior festivals, including the inaugural celebration, the New Culture of Water Queen Pageant, featuring candidates wearing dresses made from recycled materials, and the second annual CRECER competition, which saw teams of students from several of the watershed's different grade schools answering environmentally-themed questions in an academic decathlon-type format and competing for the title of "Eco-Superstars".

Oct 2014 Nectandra Institute completed eco-loan # 13, marking our first transaction with a federation of water management associations. This is also the first loan to help with the protection of land in the Colorado River watershed, which is part of Costa Rica's larger Tárcoles River basin. Our new partner, the Federación de Acueductos de la Zona Protectora El Chayote is a consortium of several water management associations in the canton of Naranjo, which overlaps partially with the

upper Balsa River watershed, our primary service area. The 21 acres of land purchased by the Federation brings to 562 acres of forest that is now being conserved or restored as a result of eco-loan assistance from Nectandra Institute. This, in turn, is improving the protection of water resources for approximately 16,000 people.

Oct 2014 Nectandra Institute iniatied a citizen science project for monitoring amphibians in our watershed and surrounding areas. We inaugurated an on line map to record amphibian sightings associated with our poster "Have You Seen Me?" Residents of our partner communities are encouraged to send picture of any amphibian encountered and post it to Nectandra Institute's Facebook page with location and date information. These reports are mapped to show the distribution of amphibian sightings in the area of interest. The information could prove useful as an indicator of climate change in light of the fact that amphibians are very susceptible to the effects of this global environmental challenge, with some species becoming extinct altogether.

Nov 2014 In mountainous, tropical countries such as Costa Rica, highland forests are critically important in the hydrological cycle. The vegetation on slopes absorbs rainfall and heavy mist, reduces surface runoff and increases ground water filtration and feeds the area's springs, streams and rivers. During this month, residents from our partner communties completed the bi-annual water flow rate measurements of springs and rivers located on or downstream from the properties acquired with eco-loan financing assistance. The longtitudinal data will help us understand the influence of the restoration on spring and surface water .

Dec 2014 Nectandra Institute helped organize the fifth annual "Conteo Navideño del Bosque Nuboso de Occidente" (Audubon- Christmas bird count in the San Ramón area of Costa Rica). Nectandra Institute is a founding organizer of this yearly event together with the Fundación Bosque Nuboso de Occidente. This year, approximately 60 birdwatchers participated, breaking out into groups of five to six people each and spread out over 17 different routes, one of which passed through Nectandra Cloud Forest Preserveand another which traversed the first community-owned restoration property purchased with eco-loan financing. The official results for this year are still being tabulated, but unofficially 319 species of birds and 5391 individuals were spotted by participants along the various routes during a 24-hour period. Birds play a very important role as seed dispersers in forest restoration projects.

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