THE CRESTED BUDGERIGAR IN AUSTRALIA

by Ken Yorke 2002

The purpose of this article is to give one person's account of practical experience in the breeding of the crested budgerigar in Australia. I stress again, the AUSTRALIAN crest, bred in Australia from Australian stock without the influence of imported Crested stock.

Why the need to differentiate between Australian crested budgerigars and those bred in UK, America and Europe? Perhaps, no need at all, but one of the aims of this article is to give some basis for comparing the Australian Crest to the other forms to allow other people with expertise in the other forms to draw some conclusions, perhaps subjectively, on whether the other forms are the same mutation or a different mutation to the Australian.

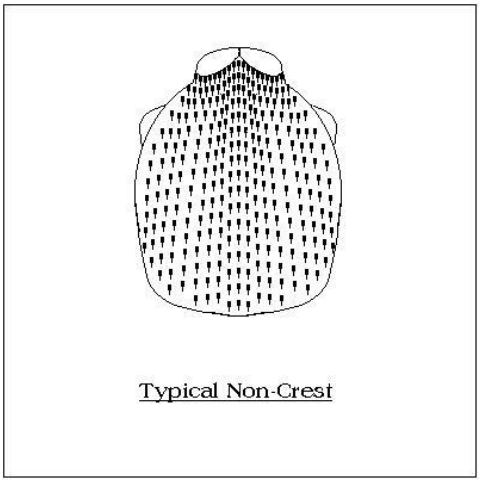
It is well documented that the first crested mutation occurred in the 1920's in Australia and that it was exported to England. Crests also appeared in other parts of the world after this time and it is still not totally clear to this day whether these birds were several new, but similar mutations, or still the original Australian mutation.

My own crests predominantly date back to a single foundation pair of birds (a Tuft and a Crestbred) purchased in Melbourne in the early 1980's. The previous owner of these birds claimed that they were directly descended from crested birds bred in Melbourne in the 1930's but he had no documented evidence for that claim. The persistence of this particular line of crested birds was actually owed to several breeders who were ironically mainly canary breeders and bred the crested budgies as a sideline. I say ironic, because in Australian caged bird circles at least, budgie breeders are generally seen as second class citizens by canary breeders and yet these canary breeders were partly responsible for keeping alive what was at one time one of Australia's rarest budgerigar varieties.

A couple of years later this original pair was supplemented by another pair (again a tuft and a crestbred purchased in Sydney from different families). As I had no Half Circular or Full Circular birds it was necessary to inbreed my existing crestbred and

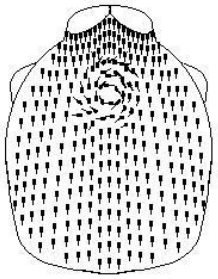
tufts in order to work my way up the perceived genetic ladder of inheritance to breed Half and Full Circulars of my own. The level of inbreeding undertaken can be seen by the fact that 20 years (and approximately 10 generations) later most of my crested birds have the original foundation pair in their pedigree over 20 times and still contribute around 20% "blood" to the current birds. In fact, if you include the second foundation pair these 4 birds still contribute around 25-40% blood of all my current stock. By comparison, in a pure outcrossing breeding programme, a bird at the 10th generation ancestor level only contributes about 0.2% "blood" to a current bird. (The quoting of such "percentage blood" figures is a dubious practice as it does not necessarily reflect the percentage of inherited genetic material but, I use the "percentage blood" system here merely to give the layman an idea of the level of inbreeding).

In later years a couple of other tufts and a full circular were purchased as outcrosses but these newer birds were generally not prolific breeders and contributed only a little to the current birds. All stock was of Australian origin, with no known imported genetic material. This was all before the early 1990's at which time legal importation of budgerigars (including Crests) from England began. This short personal history of my stock is given just to help substantiate their claim as being an Australian strain with negligible chance of foreign strains having any influence. It should also be put in the context that until the 1980s there was probably only about 20 people breeding crested budgerigars in Australia and of those only a handful had sustainable colonies of them.

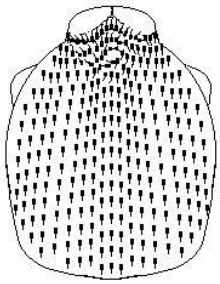


Typical Non-Crest

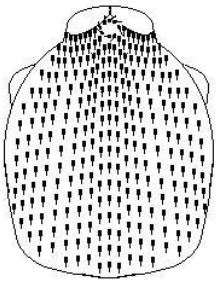
What then are the physical characteristics of the Australian Crested budgerigar?



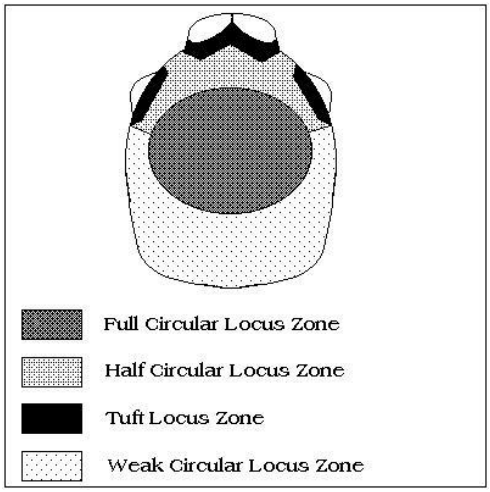
Typical Full Circular Crest



Typical Half Circular Crest



Typical Tufted Crest



I am not aware of any microscopic examination of the structure of the Australian crested feathers ever being done, but certainly at the macro level to the naked eye, the feathers which make up a crest do not appear to be structurally different nor different length, they are merely subjected to a change in direction of growth. The feathers also are not twisted along the quill axis, i.e. the down in the feather still faces the skull and the natural curvature of the feather still follows the curvature of the skull. On a very small number of tufts the impression may be that the feathers have been twisted in the quill axis but this is not the case, it is a case of the lay of the feathers physically interfering with which other. This is unlike crests in some other bird species where the tuft or comb on the head does have longer feathers and also some research on budgerigar crests in Europe [2] apparently showed different characteristics in feather structure and length.

In a recent crude survey of head feather length of my birds. I compared the length of distorted and non-distorted feathers from visual crests on the same birds (and against different birds) and against Normals and Crestbreds and found that all the feathers were within 2 mm of the same length across the whole range of Crest and Non-Crest birds. The only exception to this being from my very best Normal exhibition birds which actually had feathers 6 mm longer than the rest of the group.

One has to bear in mind that these exhibition birds where selectively bred for increased feather length.

The best time to see the feather formation is at 10-20 days of age. In ordinary Non-Crested chicks the feather quills grow in approximately 20 almost parallel, but slightly diverging, lines starting at the cere heading backwards. The quills and feather sheaths all point backwards. (See Figure "Typical Non-Crest").

Many people unacquainted with the variety who see a good strong example of a Full Circular Crest immediately assume that the feathers all radiate out from a central point like an asterisk. This is very rarely the case. A good Full Circular Crest actually has feather quills which grow in a pattern approximately tangential to a circle. The effect when viewed on the head of a growing chick is that the affected feathers look like the pattern made by the teeth on a circular saw blade. (See Figure "Typical Full Circular Crest") Another analogy would be, if you pressed your thumb down on the near parallel quills of an ordinary Non-Crest and then twisted your thumb through about ninety degrees the result would look similar to a full circular crest. This swirl effect can be clockwise or anti-clockwise. The more feathers affected by the swirl the stronger the crest.

It may surprise many to learn that Half Circular Crests and even Tufted Crests actually have the identical swirling mechanism as the root cause of these crests forms also. In fact, birds with multiple crests, quarter crests, three-quarter crests and feathers over the eye, all have this saw tooth swirl as the main basis for these formations. It is the size of the affected area (diameter), number of feathers, location of the centre (locus), curvature of skull, and interfering boundaries such as the cere and eyes which determine what visual form the crest will take.

Most ideals for the Crested budgerigar around the world are based on the U.K. ideals which recognise three forms, i.e. Half Circular, Full Circular and Tufted. Ideals have their place, but the reality is far different with many variations, as mentioned above, possible. In foreign countries, there have been reports of crests appearing on the saddle, back, wings and chest (sometimes known as frills). I have not seen any of these variations in my Australian crests. All my crested variations have appeared on the skull only. In fact, I have only had one chick with twin Full Circular crests (one

on top scull and a second very weak crest on lower backskull) from my "pure" Australian birds. Even this bird lost the second crest on the backskull as it matured. That is 1 chick out of 215 chicks bred.

I have had two other birds with twin crests (one crest between the cere and the eye on each side) but these were a child and great great grandchild respectively of the one and only outcross bird in my aviary which may have had UK crested genetic material in its makeup. As such these latter two examples may well have been a "hybrid " or combination of UK and Australian crests. That is 2 chicks out of 240 potentially combination chicks bred. (including the above that is 3 in 455 chicks with twin crests). I will discuss these potential combination birds in more detail later in this article.

Getting back to the "pure" Australian crest again, I mentioned above about the disappearing crest, i.e. the crested feathering that disappears with maturity. This is quite common in all crested forms wherever very few feathers actually make up the crest. As the feathers grow, initially there is little interference between the misdirected crest feathers and the nearby normal feathers, but as the feathers grow larger and physically start touching each other the sheer weight of numbers of the surrounding normal feathers will tease and straighten out the few stray misdirected feathers to the point where they cannot be seen, hence the vanishing crest. However, the majority of these particular birds will temporarily have the misdirected feathers reappear during each major moult only to often (but not always) disappear again for the same reasons.

Similarly, during major moults, depending on which feathers, in which order and how many are replaced, many better defined crests will also change shape. Half Circulars can look like tufts, Full Circulars can look like Half Circulars and vice versa. This changing of crest shape makes visual classification of crests into the nice neat ideals of Full Circular, Half Circular and Tufted types very awkward. (One even begins to wonder how useful these classifications really are away from the show bench.) In this regard, strong Full Circulars are not too bad but the "lower" forms of Half and Tufted can be confusing. For these reasons I tend to classify my crest types based on the visual appearance of the quill patterns in early nest feather (e.g. 2-4 weeks of

age) and don't change my classification irrespective of their final appearance. This early fledging stage is the only time in the life of the bird that you see the true quill directional pattern.

For these reasons it is a necessity that meticulous records be kept and that very close inspection be made of chicks when the quills are first appearing, as I am sure that many birds with weakly formed disappearing crests go unnoticed by their breeders and are disposed of as crestbreds, or worse still, as normals and hence a greater potential crested genetic resource goes wasted and distorts crested genetic theories.

How do the feather swirls result in so many types of visual crest?

The primary factors are location of the locus and diameter of the swirl. ***The larger the diameter the more feathers affected and therefore the stronger the crest.*** On a non-crest skull the emerging quills grow in approximately parallel rows but actually slightly diverge (i.e. taper further apart) the further back on the skull you go. The number of feathers per unit area of skin is less at the back of the skull than at the front. Just look at how densely packed the quills are directly above the cere compared to the density of quills on the back skull. This means that a swirl of feathers of the same diameter affects less feathers on the back skull than on front or top skull. This translates to:- ***Crests generally get weaker as the locus moves further back on the skull***.

It also means that the actual feather swirl will probably have ***slightly more feathers affected in the forward half of the circle than the back half of the circle***. Hence Full Circular crests will tend to look stronger from the front than from the rear. Accentuating this forward bias even further is the fact that normal feathers growing in the correct direction in front of the crest are more likely to oppose the lay of the predominantly opposite direction forward half crest feathers resulting in the forward half of the crest being raised slightly, whereas the back half of the circle has feathers that are more likely to go with and lay flat on top of the rear normal feathers. This means that irrespective of any genetic drivers to produce strong Full Circular Crests, the physical layout of the feathers biases the visual appearance to look more Half Circular than Full Circular. This forward bias phenomenon may also explain why I

have never seen a Half Circular Crest where the half circle faces backward instead of forward.

As the locus moves further forward on the scull and the diameter is still large, a point is reached where there are few if any normal direction feathers in front of the crest to raise the forward half of the circle. The forward half feathers tend to drop down over the cere and the rear half feathers still lie reasonably flat on the normal rear feathers. These birds tend to be Half Circular rather than Full Circular. In reality some of these birds are hard to classify. Perhaps the question should be asked, are they really different types or only a marginal variation of the same basic type?

As the locus moves even closer to the cere there isn't enough skin area to support a full swirl because of the physical boundary created by the cere, so you get a distorted shape swirl or a swirl of very reduced diameter. These larger distorted swirls near the cere tend to look like quarter circular crests or misshapen tufted crests. ***The smaller swirls near the cere tend to be tufted crests.*** In some cases with the smaller distortions and curvature of the skull at that point some quills will stick out of the skin at a slightly steeper angle than anywhere else on the skull. Quills which grow perpendicular to the skull are very rare and usually only occur in the centre or very near the centre of the locus and are also normally pushed flatter by surrounding feathers similar to the disappearing crest phenomenon mentioned earlier. At this point I should mention that although I have bred many Australian Tufted Crests, only an incredibly small number of them came even close to approaching the visual ideal of a Tufted crest used in the U.K and most other countries. In recent times I have seen a number of Tufted Crests on the show bench in Australia of U.K. Crest origin which more closely resemble the ideal. Perhaps this may be a potential point of difference between Australian and foreign crests (if they are not the same mutation).
I have never seen Tufts on the top or back of the skull, lending further support to the idea that the tuft owes part of its form due to the presence of a skin boundary (e.g. the cere) near the locus of the swirl and not due to some other unique feather structure which in theory could be duplicated elsewhere on the skull.

Another skin boundary is created at the eye and in this area the same distorted and/or reduced size swirls occur. The feathers are not as dense in this area so any crest formation is not as strong. The normal direction of feather around the eye is different (more parallel) compared to that of around the cere (more perpendicular) and this results in most distorted feathers hanging down over the eye. However I have had examples where the distorted feathers point up from the eye (usually only 1 or 2 feathers) thus being the equivalent of a weak tuft above the eye.

It may be hypothesised that the distorted feather swirl formations that form over the eye may be essentially equivalent to the tufted crests and small quarter circles etc. over the cere, as all rely on a feather swirl (usually small) very near a skin boundary.

Are there any other signs associated with crests?

In my own Australian crests I have not seen any skull malformations, or any obvious bone structure changes. This is purely an external visual observation as I have not done any skull cross-sections. I have also not seen any nervous disorders. (As an aside, I have seen birds with "backward craned" heads in another rare Non-crest family and at first glance this appears to be caused by a simple independent recessive gene). I mention these points only because in literature from foreign sources these problem features have at various times, rightly or wrongly, been associated with crests overseas. I would assume from this that they were a different crest mutation or simply families of crests that coincidentally had these other genetic traits as well.

What are the genetic rules for breeding Australian crests?

The genetics of Australian crests is not straight forward and this seems to parallel the experience of others with foreign crests. In a case worthy of Sherlock Holmes it is possibly better to work out which ways crests DON'T breed and then whatever ever possibility is left must be the answer.

As I have eluded to earlier, I am not convinced that the nice neat categories of Tufted, Half Circular and Full Circular are the right categories for the crested budgerigar as so many variations outside these 3 occur in real breeding results. Similarly, any genetic theory which tries to predict only these 3 categories, I believe

is doomed for failure. This is not to criticise the efforts of my predecessors who have studied in particular the UK crests, for the genetic theories put forward do partially match real results and are still as good as we have to date in terms of prediction of offspring.

For better or worse, in my own breeding records I included an extra category called crestbred* (with an asterisk) to highlight those birds with feathers over the eyes or weak feather distortions, because they were so commonly produced. For reasons of clarity and brevity I will use the following definitions for the remainder of this article with regard to genetic discussion.

FC = Full Circular Crest, HC = Half Circular Crest, TF = Tufted Crest,

Crestbred = Non crested bird with at least one Visual crest parent.

Crestbred* = Visual feathers around eye area or very weak feather distortions.

Normal = Non crested bird with no crested ancestry.

VISUAL = Any bird with temporary or permanent feather distortions including FC, HC, TF and Crestbred*

NV = Non-Visual (Crestbred or Normal)

If a VISUAL is bred to a normal, some VISUAL's are produced. This implies a dominant or partially dominant gene. However, if this were the case, one would expect either 50% or 100% (on average 75%) VISUAL's from such matings depending on whether the VISUAL was single or double factor for the crest gene. From my breeding data, VISUAL x normal gave only 16% VISUAL offspring (50 chicks). In fact, ignoring one possible dubious pairing in the data (which will be explained later) the percentage of VISUAL's is even lower at 10%. If a simple dominant or partially dominant gene isn't the sole driver for crest production, there must be another influence, whether it be a second gene, a lethal factor or some other non-genetic interaction.

Crestbreds also appear to retain some crest genetic instructions just as a normal split for a recessive variety does. Surprisingly, I have not ever mated two crestbreds

together to see if VISUAL's appear. However, my VISUAL x crestbred matings produced 28% VISUALS (112 chicks) which shows that the crestbreds produce nearly 3 times as many VISUALS as pure normals when mated to VISUAL's. This increase is consistent irrespective of whether the VISUAL used was TF, HC or FC.

On average, my VISUAL x VISUAL matings have produced 58% VISUALS (225 chicks). If crests were recessive it should produce 100% and if they were dominant would produce either 75% or 100% (depending on single or double factor) for an average across all possible matings of 92% crests. This is a very large discrepancy in all cases. No evidence of sex linkage has been found to date.

Lethal genes?

Interestingly, if a single partially dominant crest gene were responsible, the 58% figure above might begin to ring alarm bells, as 67% is the theoretical figure at which a lethal gene operates. Lethal genes do exist in all species and are usually noticed by the absence of double factor offspring which die at various stages of development (eg clear eggs, addled eggs, dead in shell or shortly after hatching). An example of this in the equine world is double factor overo-white and roan horses die in the womb or shortly after birth. As a sample, in an 11 year period my Normal matings resulted in 39% hatchlings from 3941 eggs, the remainder being, broken, clear, addled or dead in shell. In the same period, exposed to the same environmental conditions my VISUAL and Crestbred matings had 47% hatchlings from 791 eggs. This shows that the crest genetic matings actually had better hatchability than the Normals. This would tend to contradict a lethal gene being present in the Australian crest. However research in Europe did apparently show evidence of a lethal factor at work there.

What is my Crestbred* category?

I separately identified the Crestbred* category in order to study if these birds firstly deserved a separate category and secondly to determine if such birds were perhaps misplaced tufts or crestbreds which showed some weak visual signs (similar to the way some Normal split Recessive Pieds carry a pied head spot despite being otherwise normal in appearance). Crestbred*s were mated to FCs, HCs and TFs resulting in 44-61% VISUAL offspring. TFs were mated to FC, HCs and TFs resulting

in 50-58% VISUAL offspring. Crestbreds were also mated to FCs, HCs and TFs resulting in 24-33% VISUAL offspring. From these comparisons the Crestbred*s appear to have better crest genetic potential than the Crestbreds. Crestbred*s appear to have basically the same genetic potential as TFs. No anomalies were seen in the types of crests produced from any individual mating (however the data sample size in some cases was not great enough to determine if the percentage spread of the types was different). The fact that Crestbred* and TF are similar, lines up well with my abovementioned thinking that they are equivalent based on the swirling mechanism and skin boundaries.

A polygenic variety?

From the above, the crest shows some characteristics of both dominant and recessive breeding behaviour but neither fits the normal rules nor does it adequately explain why so many visual forms of crest appear. It has not been possible to produce strains which produce only tuft type crests or say, only circular type crests. If this was possible it could point to say tufts and circulars being different mutations which have been crossbred. This does not appear to be the case. As mentioned earlier from my findings and the diagrams given, all Australian crests of all visual types appear to have the same basic feather swirling mechanism, so it is more likely that the same gene is responsible. There must be another driver (probably a second or third set of genes) which controls either the location or size of the swirl and thus cooperatively controls the final visual type of crest.

The Australian crested variety then appears to have all the trademarks of a polygenic variety. At least one or more sets of genes appears dominant or more likely partially dominant. This is a similar conclusion to what many others before me have come to with regard to the U.K crested mutation. With any polygenic characteristic, the individual genes still follow Mendelian genetic laws but the number of potential combinations quickly escalates to a point where each specific combination is not obviously or separately identifiable. (Overall body size and shape is an example of polygenic effects in all species.) Hence the results of such matings observed over a large population tend to show continuous variation in a typical bell shape curve distribution with a mean and extremes in either direction. This appears the case in

the Australian crest where the extremes are Crestbreds (or very weak distortions) up to multiple crests. By careful selection a skilled breeder can push the mean in one direction or another (i.e. the strain may produce more FC's and multiple crests than a strain bred to produce mostly TFs).

Is there more than one crest mutation?

In 1994 I was given a single normal budgerigar cock (subsequently identified as No 1662) which was the first or at most the second generation bred from English imported stock (i.e. no Australian blood whatsoever). I was given this bird to experiment with because it consistently had one feather hanging down over one eye. The pedigree of the bird displayed no known crested ancestors. Bird 1662 was subsequently mated to 3 different Australian hens (2 HC and 1 TF). The resultant offspring were 1 FC, 1 HC, 1 Crestbred*, 4 Crestbred and 1 Strong Twin Crest. As he produced 50% VISUALs I deduced that he likely carried either the Australian Crest gene/s or another crest mutation compatible with it. It was unlikely that 1662 was pure normal based on the single feather and the high percentage of VISUAL offspring.

The Twin crest produced (No.1871) was the first such permanent twin crest I had produced. The second and only other permanent twin crest (No. 3013) I have bred to date was a great grandchild of 1871 which also had other inbred ancestors to 1662. Bird 1662 appeared in the pedigree of this bird 3 times. These twin crests MAY have pointed to 1662 having a second crest mutation instead of, or as well as the Australian crest mutation in his genetic makeup.

From 50 chicks bred from VISUAL to Normal matings I have produced 2 HC, 2 TF, 4 Crestbred* and 42 Crestbreds. The 2 HCs came from a single pair. No other pair have ever produced HCs where one parent was a Normal. The Cock bird (No. 1726) of this particular pair had feathers over the eye and was a son of 1662. 1726 also appears twice in the pedigree of the twin crest bird 3013.

It is noteworthy from this that the only few deviations from the norm I have ever seen in my Australian crest birds are all direct descendants of bird 1662 and all these deviations have been toward producing "higher order" crests. One possible

explanation is that bird 1662 had a second crest mutation in its genetic makeup. In this way, crossing 1662 with Australian crests may have created a "hybrid" or combination crest. As this bird was of English heritage, this lines up well with anecdotal evidence [1] that the current crested bird in the U.K. is a combination of 2 or 3 mutations, one of which I believe is probably the Australian mutation. My genetic data from matings appears extremely similar to what data I have seen of the UK crest so again perhaps the Australian crest is part of the makeup of the U.K. crest. Since the legal importation of U.K. crested budgerigars into Australia in the early 1990s many of the crests on the show bench today in Australia are already a combination of U.K. and Australian crested "blood"

Conclusions

The conclusions I draw are based solely on my own family of Australian crests and I cannot speak for other breeders' experience with either Australian or foreign crests. In fact, I actively invite the comparison of my experience to others in the hope that either some hard evidence or at best consensus on some issues can be achieved.

1) The primary cause of all Australian Visual crest feather formations is the saw tooth swirling mechanism which changes direction of feather growth.
2) The visual expression of the feather swirl is affected by size and locus location, including interaction with skin boundaries such as the cere and eye resulting in many visual forms of crest.
3) A partially dominant gene is the likely root cause of this swirl mechanism assisted by one or more other genes, thus creating a polygenic variety.
4) There is insufficient evidence of pleiotropic effects (i.e. multiple characteristics) such as lethality, nervous disorders etc.
5) The neat categories of Full-Circular, Half Circular and Tufted have marginal relevance outside the show bench, as many other variations are possible (both visually and genetically).
6) Of far less certainty, I suspect that the modern U.K crest is a combination of the Australian crest and possibly another crest mutation. The Crest mutation studied by Ziswiler in 1963 and referred to by Onsman may be a different mutation to the Australian.

Unfortunately, not enough data has been collected nor will probably ever be collected to conclusively prove or disprove many of the above hypotheses and conclusions. Several alternative explanations are still possible. The true answer will probably never be known until genetic science produces an accurate gene map for the budgerigar.