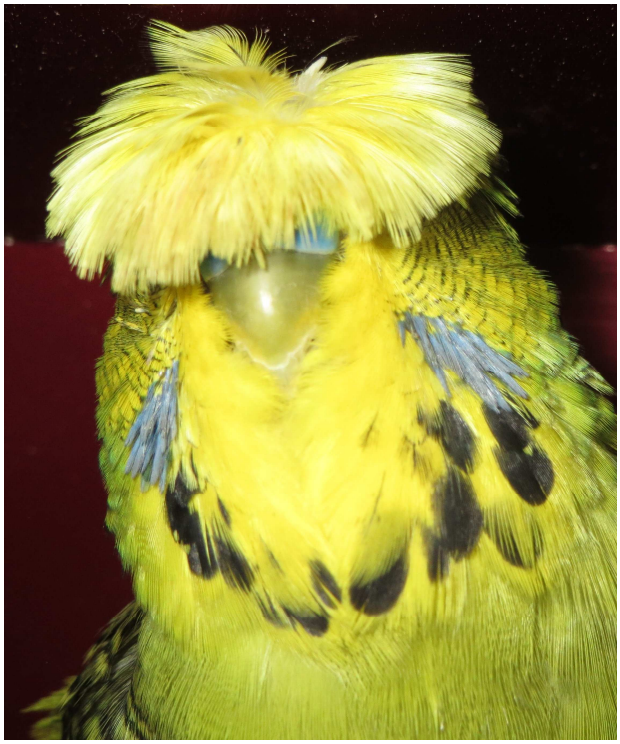
The Crested Budgerigar Club of Australia

Handbook



2nd Edition

Edited and compiled by
Ken Yorke, Robert Hugo, George Clarke

THE CRESTED BUDGERIGAR CLUB of AUSTRALIA

Founded – 1993
Recognized by the ANBC 1994

CBCA Office Bearers 2014/2015

President	Roy Blair
Vice President	Warren Wilson
Secretary	Rob Hugo
	26 Okewood Way, Morley, W.A., 6062
Treasurer	Rob Hugo
Editor	Rob Hugo

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PREFACE
to 2nd Edition

The 1st edition of this handbook published in 2002 represented a major milestone for the Crested Budgerigar Club of Australia (CBCA). It was a testament to the substantial effort undertaken by former club President Frank Jeffries in its preparation with assistance from Ghalib Al-Nasser, Past President of the Crested BC (U.K.). More than a decade on, this revised 2nd edition retains some material of the 1st edition but by necessity reflects the passing of time within the club and the progression of the crested variety since.

During this time, members of the CBCA have been active in the research of the crested variety. In 2002 Ken Yorke produced a major article "The Crested Budgerigar in Australia" [14] detailing his several decades of experience with the variety. This inspired George Clarke to undergo a substantial data collection and statistical analysis of breeding records involving over three thousand crest related progeny. This analysis resulted in a series of articles by George between 2004 and 2011 [1 - 6, 20] detailing his PE Theory. In more recent times Don Burke has studied the recent advances in genetic science in all species and applied these principles to Cresteds. Don has also researched parallels between crest feather formations and hair whorls in mammals. Elements of the above research and commentary have been incorporated into this 2nd edition of the Handbook.

The focus of the revised Handbook is Crest-specific information. Some previous content has been omitted; new content has been added; existing content has been revised. Chapter 4 of the 1st Edition, "Genetics and Colour Breeding for Budgerigars" has been omitted, the content being widely available in most standard budgerigar texts and covered comprehensively in Taylor & Warner's "Genetics for Budgerigar Breeders" [13] and more recently in Dr Terry Martin's "A Guide to Colour Mutations and Genetics in Parrots" [17]. Every effort has been made to acknowledge significant contributions from external sources.

An earlier attempt to revise this Handbook in 2009-2012 involved a major effort by George Clarke with assistance from Bob Burke and Rob Hugo. That version unfortunately was not completed due to personal circumstances, not the least of which was the untimely death of then CBCA President Bob Burke. This 2nd edition completed by Ken Yorke and Rob Hugo incorporates a large amount of text authored by George Clarke from that incomplete version.

Ken Yorke, Robert Hugo , George Clarke 2015

Chapter 1

HISTORY OF THE CRESTED BUDGERIGAR CLUB OF AUSTRALIA

The Crested Budgerigar Club of Australia owes its foundation to an original idea and the efforts of Shiralee Reardon to popularise the Crested Budgerigar in Australia in early 1992.

The following article relating to those early days was written by Shiralee.

"If you are dissatisfied with anything there are two things you can do, forget and walk away from it, or decide to do something about it. The latter idea was to eventually lead to the formation of The Crested Budgerigar Club of Australia in May 1993.

When I first became interested in the Crested Budgerigar, I was both surprised and disappointed about how little information there was on the variety. Most books either did not bother to mention them, or simply made a vague remark about their existence.

Very few breeders had any experience with them. In fact most of my fellow breeders thought I was crazy to even think about breeding them, and even worst - to actually voice this out loud in public. No one knew where to purchase a Crest from, and no self-respecting breeder would bother with these birds.

No wonder no one wanted to breed Crests in Australia - they are as rare as hen's teeth and if you are able to find some, there was no information on how to breed them. The poor old Crest bird was right behind the eight ball.

If things were this difficult for me in South Australia, it was probably the same throughout Australia. I wondered how many others were breeding Crests Interstate, and how could I find out? I decided to get the addresses of as many major Interstate Budgerigar Clubs as I could and send off a questionnaire to their members, which simply asked 'Do you breed Crests, and would you be interested in forming a club devoted to Crests?'

After several anxious weeks the replies slowly started to come in, and yes, there were others out there breeding them and yes, they were interested in forming a club. Several were coming to Adelaide for the National Championship Show (which is held in a different State each year in May) and suggested a meeting be held there.

I stated that if the club was to be formed, I hoped we would be able to achieve the following:-
1) To gather and distribute information to other interested breeders,
2) To have a list of breeders who would be able to supply other members with Crested birds and
3) Eventually to breed the birds up to an acceptable standard to become a class in the National Championship Show.

This was in May 1993; nine people attended the inaugural meeting where we decided on forming a club, its name, subscription price, etc. Thus was the beginning of The Crested Budgerigar Club of Australia."

Inaugural CBCA meeting, Adelaide 1993,
Left to right - Ken Yorke, Ken Hall, Shiralee Reardon, Frank & Gay Jeffries, Rob Hugo.

In 1994, within twelve months our membership had nearly doubled; and with the help of our Western Australian members we were able to stage our first Show. The club had been granted permission by the WABC (Western Australia Budgerigar Council) to hold an exhibition class show in conjunction with the Australian National Championship Show. A lot of work was done by a few West Australian members in particular Rob Hugo ensure that our first Inaugural Crested Show was successful. The Show (with a staggering 53 crested birds

from all over Australia were entered) proved to be a great success, both for our club and the Crested variety.

We were also very lucky that Ghalib Al Nasser from the U.K., one of the leading authorities on Crests was present as a guest speaker at the Australian National Championship Show. He kindly accepted our invitation to judge the major awards and gave us some hints and encouraging words of advice, regarding our desire for the crests becoming an official class at the National Show. It was befitting that the Best Crest award went to Shiralee Reardon at this first crested show.

The other major achievement in 1994 was that the ANBC (Australian National Budgerigar Council) recognised the Crested Budgerigar Club of Australia as a body working for the benefit of this variety.

During the following two years Shiralee Reardon organised two very successful Crested Lawn Shows at her parents' home for the South Australian members. Each event had a Crested Show and crests for sale, all were well attended with over 50 budgie breeders at each Show. The free scones with jam and cream might have helped too. Nevertheless it got the crested breeders together, and more non-crested breeders to look and talk about the variety and raised a couple hundred dollars from the raffles and door prizes.

In more recent years the Victorian members especially Darren MacFarlane, has had a major success by being able to hold their first Annual (hopefully) Show in conjunction with the BCV Adult Bird Shield Show.

Also in the last few years two of our New South Wales members, have been very active in promoting the Crested variety by organising Crested Seminars/Lectures. In particular Frank Jefferies has been foremost in assuring the interest in the crested variety continues through these activities. Warren Wilson has also helped maintain the interest in this variety by organising several Seminars at the club level.

At our AGM in 1999, after several years of Shiralee Reardon being President/Secretary/Treasurer / Membership Officer and Editor all rolled into one, it was decided the load should be shared and the club put on a more professional footing by the election of several office bearers. The following were elected to the newly created positions, President Frank Jefferies, Secretary/Treasurer Rob Hugo and Editor Shiralee Reardon.

In May 2000, the club finally was able to celebrate a major victory; the Crested variety was finally going to become a National class at the Australian National Championship Show in 2003, this following a three year invitation class at the National Show.

Major milestones/achievements for the club in following years include:-

- In 2002, with the support of the Crested Budgerigar Club UK, the club published the 1st edition of this Handbook.
- In 2003 the club finally achieved its ambition to see the inclusion of the Crest as an exhibition Class in the Australian National Championships.
- Publishing a twice yearly magazine "The Full Circle".
- The club, through the efforts of Rob Hugo, has established its own website. http://crestedbcaustralia.com/resources.html and a Facebook page "The Crested Budgerigar Club of Australia"
- Establishment of a nationwide competition (The Golden Crest Award) to promote the crested variety at local club exhibitions.
- Research by club members has led to the production of this updated 2nd edition of the Handbook.

The club has a lot of people to thank for the help and assistance in keeping the club going, helping to maintain an interest in the Crested variety, and their assistance at a National level in regard to the Crested variety becoming an official National class. Their help has been invaluable and it would be impossible to list and name them all, but the club does thank them for their tireless efforts.

One could argue that these people may have saved the Australian Crested Budgerigar from extinction. Who knows how long people would have continued breeding these birds when at one stage they were the only Standard bird not to have a class at the National Championship Show. All members should take pride in the fact that we have established a recognised Specialist Club, and through it we have lobbied for and have achieved a class for the crests

To summarize, the progress and success of The Crested Budgerigar Club of Australia since its inception has been very impressive. We have achieved what many thought impossible, a class at the National. Our membership has grown, and we have a cross section of members from the raw beginners to the very experienced, we even have National Judges amongst our members. There is still much to be done to promote the Crested variety and all our members can be a part of this, by simply breeding the exhibition standard of Crested Budgerigars.

Chapter 2

ORIGINS AND EARLY HISTORY OF THE CRESTED BUDGERIGAR

There are various published versions of the origins and early history of the Crested variety. It is generally agreed that the first Crested mutation occurred in Australia. It remains unclear whether there was just one original mutation which was subsequently exported to other countries, perhaps via unrecognised Crestbreds, or whether several genetically compatible mutations occurred around the world, each possibly giving rise to slight variations in the form of crest. Genome sequencing may eventually throw some light on this issue but the extensive interbreeding of crests from different countries will make this task difficult. The history included below is a composite of the version contained in the 1st edition of this Handbook, the version in the Handbook of The Crested Budgerigar Club (UK) 1995 [15], and other reports.

The CBCUK Handbook quotes the first Cresteds being bred in Sydney, Australia in the 1920s, but gives no reference to the source of this information.

The first confirmed reference is from "Australian Cage Birds", 21November 1936.

> *"A visit was paid by your Budgerigar contributor to the aviaries of Mr. Mathews, of Kogarah, to inspect this latest mutation, and there is no doubt that the crest is here to stay.*
>
> *Both Mr. and Mrs. Mathews very kindly gave all the information they had, which is most interesting. The original bird had a very slight disturbance on the crown of its head, so slight that it would never be noticed unless pointed out. It was also unnoticed by the owner until, after returning from a fortnight's holiday, he looked at the youngsters in the next box, of which this bird was the father, and lo! There were some crested young.*
>
> *These young have a definite crest, and now they are parents themselves, making the third generation with crests. The definite three stages are obvious, each one being a big improvement on its parents. And now in the third generation we can definitely look ahead to a really beautiful crest being evolved, and there is no doubt that two of three more generations will work wonders. The crest has improved to such an extent that there can be seen two lines of zebra markings a little paler than those on the back of the head, but definitely there, and running in two circles around the crest, one within the other. Another bird has the faint markings only on the rear portion of the crest.*

Right in the centre is the pinpoint from which the feathers radiate, much more conspicuously to the front than to the rear, giving a look of a brow over the eyes.

It is quite evident that in the progress made in only three generations. Mr Matthews (and his good wife) do not require an instruction or advice as to procedure in order to successfully propagate this most interesting and latest mutation, It is probably quite safe to congratulate Mr. and Mrs. Matthews for having evolved something new in Budgerigars for the first time in the world."

The second account appeared in the "Budgerigar Bulletin" of December 1938 from Mrs R Brown of Morecombe, Lancashire, England.

"Now that I have introduced to budgerigar breeders in this country the crested type, I think it will be of interest to say the appearance of this new variety was purely accidental. Mr. Matthews, of Kogarah, New South Wales, noticed that one of a brood of Yellow-Whites, from parents of just ordinary importance, had the feathers on the head curled towards the front and sides, giving the appearance of a crest in the making. By the time this bird reached maturity the crest had improved to such an extent that Mr. Matthews realised he possessed a budgerigar of outstanding importance. He therefore set out to propagate a crested group. This crested bird, a female, was paired to a male of similar brood to its father, and from this mating only one of the youngsters, a male, showed signs of crest, having a few feathers turned the wrong way on the top of its head. This bird, when matured, was paired to its mother; from this mating there were crests, half-crests, and split crests. Mr. Matthews has now in his aviary crests of the third and fourth generation. He is to be congratulated on definitely establishing this new variety."

There are reports of Crested mutants appearing on the European continent just prior to the Second World War, and the birds were exported to Great Britain in 1939. These birds became known as the "Continental" strain.

From the CBCUK Handbook:-

"It would seem that the British Crests have been developed by combining the Australian and European strains." [15]

"A further crested mutation was reported as having appeared in Canada around 1948. There seems to be some confusion as to the exact location of this mutation as some people say it was in the aviary of Mrs. V.B. Knights of Nova Scotia and others, in another establishment in

Toronto. The most likely explanation is that both locations had crested birds from a single source. It is not definitely known if any birds from the Canadian mutation came to Europe. However British bred crested stock was sent to Canada and they were found to have the same breeding pattern as the Canadian birds." [15]

These birds regardless of where they first appeared were to become known as the "American" strain. It is believed that the Cresteds in the United States are descendants from these birds. Crested birds were smuggled into the United States from Mexico. These Cresteds, in Mexico, were descendants from Cresteds imported from Canada in the early 1950's.

"The 'Continental' strain and the 'American' strain..... differ only in the position of the centre (or locus) of the crest. The Continental strain has the centre of the crest just above the cere, resulting in a strong splay of feathers which bend over the head down to eye level. The American strain has the centre of the crest slightly further back on the head, resulting in the feathers standing more or less upright with a splay only at the ends, if at all. But over the years the two strains have become intermingled such that either strain can produce the other." [15]

In the mid 1980s a form of Crested variety was developed in Japan having a strong crest formation on both the head and the back and/or wings. Amongst several names given to these were Japanese, "Heavenly Robe" or Helicopters. These birds were exported initially to Germany and then to numerous other countries where they have become increasingly popular in Asia and the Middle East, but less popular in other countries.

Chapter 3

CREST TYPES

Exhibition Types

For exhibition purposes the Australian National Budgerigar Council recognises three types of crest on the head of Crested Budgerigars and has a standard pictorial ideal for each. Copies of these pictorials are included in this Handbook.

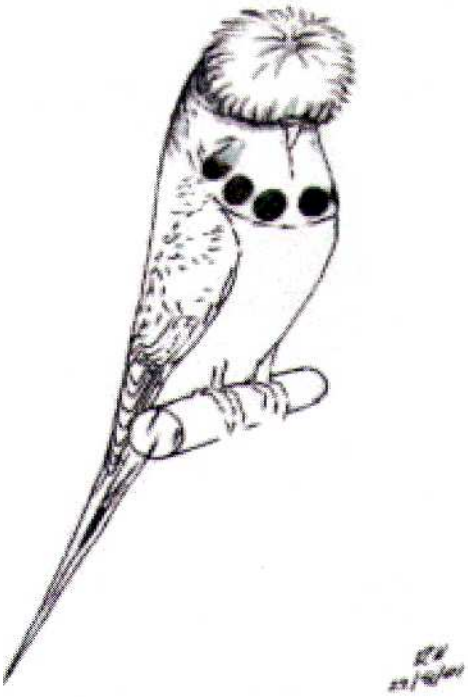
i) The **tufted** crest consisting of a small to medium number of feathers rising mainly upward from directly above the centre of the cere.

ii) The **half-circular** crest consists of a medium number of raised or falling feathers around the front of the head in a half circular shape. The back head-feathers lie flat to the head.

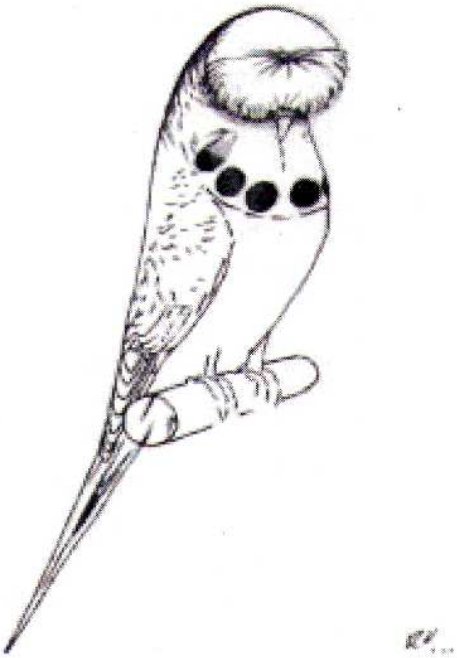
iii) The **full-circular** crest consists of a medium to large number of feathers, emanating from the centre of the head forming a full round crest. The feathers at the front of the crest may be raised or falling. The feathers toward the rear are generally falling and more prominent than in half circular crests.

Quoting from the CBCUK Handbook:-

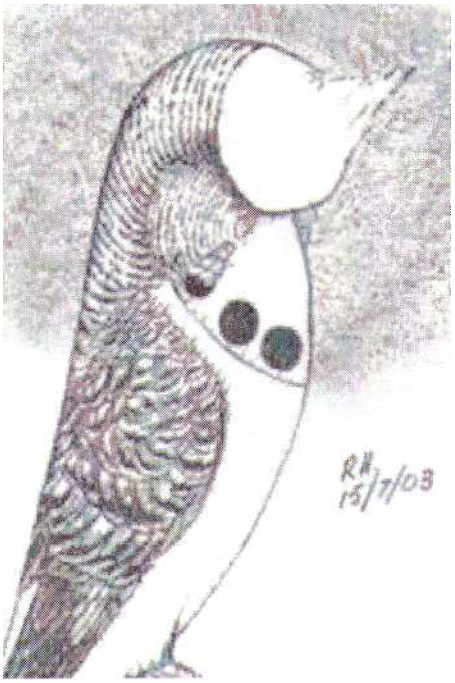
> *"Although these are the only recognised types of crest for budgerigars, no crest is exactly like another, even those of the same type. The range of the degree of feather disturbance in tufted crests is wide; some tufted crests only appear to have an odd feather or two out of place whilst others have a thick clump.....*
>
> *Differences between half-circular and full-circular crests can be minor but usually the two types can be differentiated by examining the back of the head. However, there will be borderline cases.....*
>
> *On some circular crested birds the feathers actually overlap the eyes (as they do on Gloster Canaries) and the crest presents a soft, delicate look like a powder-puff; whilst on others the crest feathers are more jagged in appearance yet retaining the same circular shape.*
>
> *A shift in the locus of the crest also has the effect of making the crest look different. Thus if the locus is slightly off-centre, either to the left or the right, the crest comes out at a lopsided angle. This gives the impression of a man's hair parting in the case of the tufted type and a woman's saucy hat in the case of the circular types."* [15].

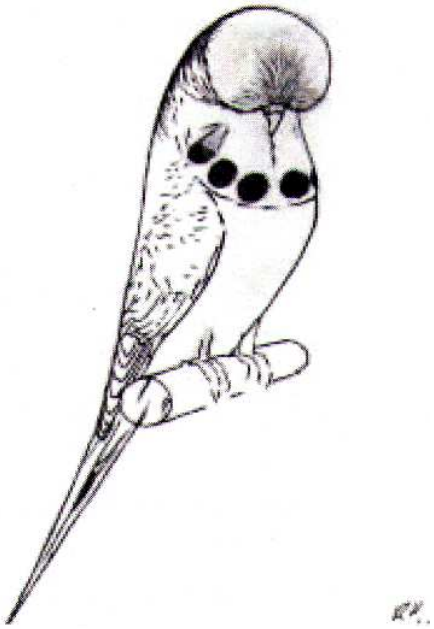


Full Circular



Half Circular





Tufted

Australian National Budgerigar Council Standard Crest Pictorials

Drawings Courtesy of ANBC [16]

Non-Exhibition Types

Crested feather characteristics have also occurred on areas other than the head. Swirled feathers can be seen on the chest, shoulders, back and/or wings. All these forms have been generally called Frills or Frilled. The feather appearance varies from a frill or fringe, to petals of a flower, to a circular crest. As with head crests, the locus can move around giving different appearances. The vast majority of Frills have both a crest on the head and on the body at the same time. Frills with small fringes or petals have been nicknamed as "BackFrills". Frills with stronger "flowers" on the mantle or wing butts have been nicknamed as "Japanese" or "Helicopters". An extreme form of this, not seen in Australia, with crest formations closer to the extremities of the wings have been nicknamed "Pharaohs". Frills are currently very rare in Australia.

Multiple loci are quite common whereby more than one crest feather formation occurs on the head resulting in double crests, triple crests etc. All these forms are generally called "Multi-Crests". Each feather formation often interacts with the other resulting in misshapen crests. Frills also often have multiple feather formations particularly on the shoulders and spreading to both wings. Confusingly, overseas the term "Frilly" (or even "Frilled") is sometimes also used for Multi-Crests where each "circle" of feathers is not well formed and interacts with each other.

Frills and Multi-Crests are currently not standardised for exhibition purposes in Australia nor most other countries.

General Crest Forms

Breeders have long recognised that actual Crest forms extend beyond the recognised exhibition types. [8] [9] & [14]. The feather disturbances causing the visual Crest do not create just a few uniquely recognisable crest forms. Instead there is a continuum of many phenotypes ranging from a single displaced feather to multiple crests. Classification into just three common types became entrenched because of,

(a) the need to define "ideal" types for exhibition purposes,

(b) the fact that most breeding results have been reported in terms of just these three types, and

(c) the difficulties finding a simple genetic model to cater for any greater number of types.

Some weak forms are only recognisable while the chick is in the nest; thereafter no sign of crest is visible. These are known as "temporary" or "disappearing" Crests.

There is another important non-visual Crest type that plays a major role in Crest breeding plans. This is the **Crestbred**. These birds never show any visual crest

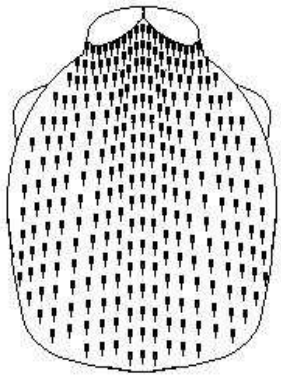
characteristics but may, or may not, carry Crest genetic material. Crest-breds are visually indistinguishable from Normals (non-crested).

Crest Formation.

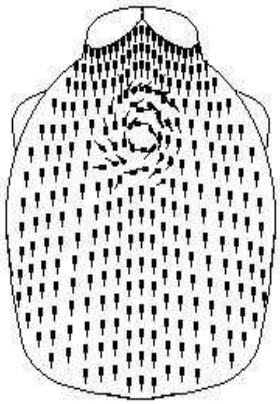
Australian Crest breeder and foundation member of CBCA, Ken Yorke has studied and documented the formation of crests in the Australian Crest. The following paragraphs are a direct quote from his 2002 article. [14]

> *"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 each 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 [12] 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 2mm 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 6mm 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.



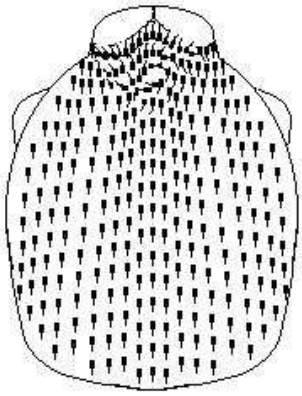
Typical Non-Crest



Typical Full Circular Crest

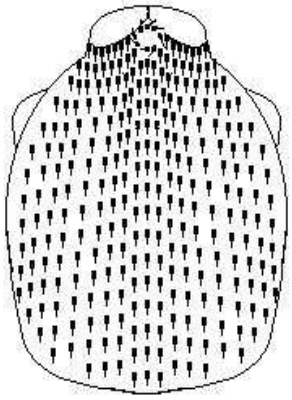
It may surprise many to learn that Half Circular Crests and even Tufted Crests actually have the identical swirling mechanism as the root cause of these crest forms also. In fact, birds with multiple crests, quarter crests, three-quarter crests and feathers over the eye, all have this saw tooth swirl 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.



Typical Half Circular Crest

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.



Typical Tufted Crest

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?

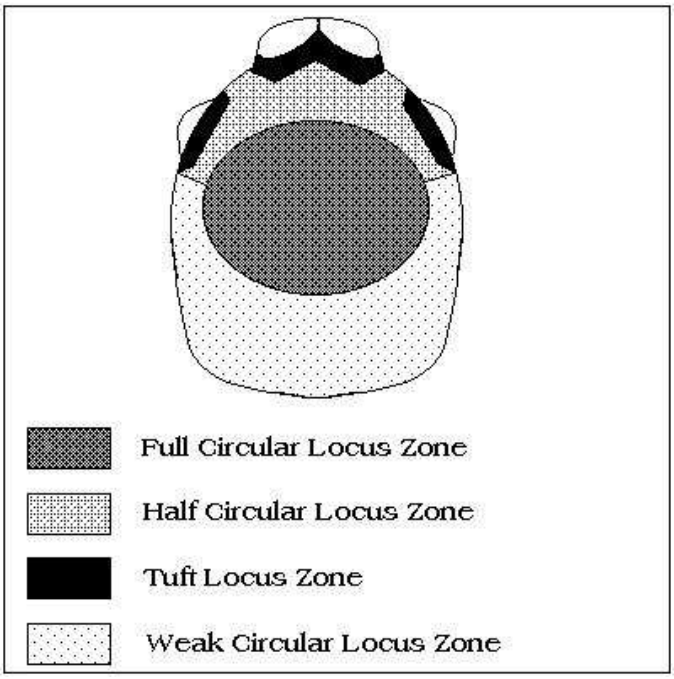
The primary factors are location of the locus and diameter of the swirl. ***The larger the diameter the more feathers affected and therefore the stronger the crest.*** *On a non-crest skull the emerging quills grow in approximately parallel rows but actually slightly diverge (i.e. taper further apart) 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 (eg 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." [14]

Tufted

Half Circular

Half Circular (off centre)

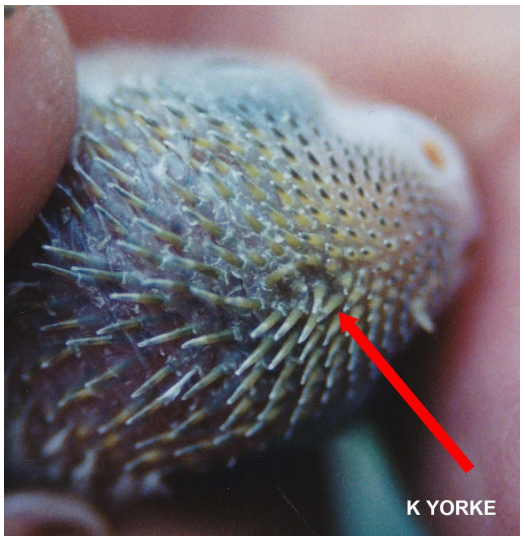
Full Circular

Twin Full Circulars (merged)

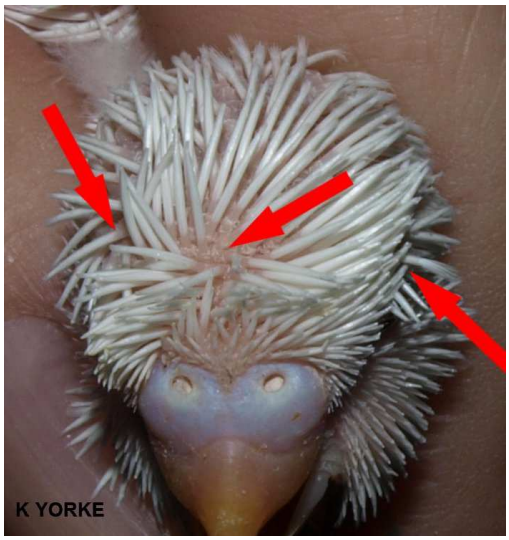
BackFrill (with multi-crest on head)

Helicopter

Pharaoh



"Disappearing" Crest
(2 feathers)



Triple Crest
(half circle +2 quarter circles)

Chapter 4

GENETICS OF THE CRESTED BUDGERIGAR

Chronology of Genetic Theories

The genetic breeding rules of the Crested variety are like no other budgerigar variety, it is neither dominant, recessive or sex-linked in its mode of inheritance. Many theories have been put forward over many years as to its genetics with moderate success. To this day the exact genetics have not been proven beyond all doubt but with each iteration of existing theories and new ideas being developed we get closer. Despite this, there are some models and guidelines which are useful in predicting the progeny from many Crested matings.

This chapter will do a chronological review of the genetic theories and models which have been put forward over time including the latest research and also other issues relating to Crested genetics.

Quoting the CBCUK Handbook:-

> *"The first pioneer with Crested Budgerigars in the U.K., Squadron Leader S.A. Lucksford published his breeding results in "Cage Birds" on 6th November 1958 and 26 January 1961. He classified his birds as Normal, Crest-bred and Crested but made no distinction between the different types of Crests. As he had obtained some crested from a pair of non-crested birds it was clear that the crested gene was not a simple dominant gene. In a reply, (Cage Birds of 23rd March 1961), C. Warner and Dr. T.G. Taylor urged that breeding results should define the type of crest, and suggested that crest inheritance might be something like the inheritance of the Single, Pea, Rose and Walnut types of fowl's combs, which depend upon different combinations of two dominant genes and their two wild-type alleles (alternative forms). But, in the absence of suitably classified results it was impossible to present a detailed theory.....*
>
> *D. Burke, of Sydney, in "Budgerigar" (published by the Budgerigar Society of Australasia) of August 1963, and in the CBCUK Newsletter Vol.1 No. 5 -1965, regarded all birds as either Full-Circular or not Full Circular, and postulated two genes in the visually crested: - one that gives the bird its crest and the other which allows it to show it visually. But the ideas were neither worked out in detail nor formulated."* [15]

In 1963 Dr V Zisweiler of the University of Zurich, Switzerland published a thesis stating that Cresteds were due to a single partial dominant gene. Single factor birds thus had one crest and double factor birds had two crests. He also claimed that the Crested gene had some lethal aspects. This thesis has since proven to be completely inaccurate.

The **Inhibitor Theory** was the first fully developed theory to emerge based on a two dominant gene model. In May 1964 an article by Dr J.E. Fox of Kansas University U.S.A was published in "Cage Birds" explaining the theory. A.F. Fullilove and C. Warner arrived at a similar theory at about the same time.

J.E Fox revised the Inhibitor Theory slightly in an article in the Crested Chronicle (June 1970) to form a new theory known as the **Initiator Theory.** J.E. Fox labelled his two genes as Crest Determiner (Cd) and Crest Initiator (Ci) with Cd+ and Ci+ being their wild type alleles. This theory had 9 genotypes being 2 Full Circular, 1 Half Circular, 1 Tufted, 4 Crestbred (i.e. birds without visual crests but still retaining crest gene/s) and 1 pure Normal.

The Table 1 shows the full listing of possible matings for the Initiator Theory.

Table 1 - Initiator Theory Matings

CRESTED BUDGERIGAR MATINGS AND EXPECTATION TABLE

To use the Table:-

Find the two varieties of a particular pairing, one on the left hand column and on the bottom line. Where the horizontal and vertical lines from these two squares meet will be the expectations for the particular pair. These expectations will not necessarily be accurate for one nest, but if taken over a number of nests should be reasonably accurate.

Example: Half-Circular X Half-Circular
This genotype 3 X genotype 3
Draw a horizontal line from genotype3 square in the left hand column and a vertical line from genotype3 square in the the bottom line. Where the two lines meet will be found the expectations from this mating.

i.e. ½ Half-Circular (genotype 3)
¼ 2 factor Circular (genotype 1)
¼- Crest-bred (genotype 5)

1 Circular 2F Cd Cd Ci Ci	All-1								
2 Circular 1F Cd Cd+ Ci Ci	½-1.2	½-2 ¼-1.7							
3 Half-Circ. Cd Cd Ci Ci+	½-1,3	¼-1,2,3.4	½-3 ¼-1,5						
4 Tufted Cd Cd+Ci Ci+	¼-1,2,3,4	¼-2,4 1/8-1,3,7,8	¼-3,4 1/8-1.2,5,6	¼-4 1/8-2,3,6,8 1/16-1,5,7,9					
5 Crest-bred Cd Cd Ci+ Ci+	All-3	½-3,4	½-3,5	¼-3,4,5,6	All-5				
6 Crest-bred Cd Cd+ Ci+ Ci+	½-3,4	¼-3,8 ½-4	¼-3,4,5,6	¼-4,6 1/8-3,5,8,9	½-5,6	½-6 ¼-5,9			
7 Crest-bred Cd+ Cd+Ci Ci	All 2	½-2,7	½-2,4	¼-2,4,7,8	All-4	½-4,8	All-7		
8 Crest-bred Cd+ Cd+ Ci Ci+	½-2,4	¼-2,4,7,8	½-4 ¼-2,6	¼-4,8 1/8-2,6,7,9	½-4,6	¼-4,6,8,9	½-7,8	½-8 ¼-7,9	
9 Normal Cd+Cd+Ci+Ci+	All-4	½-4,8	½-4,6	¼-4,6,8,9	All-6	½-6,9	All-8	½-8,9	All-9
Variety	1 Circular 2F Cd Cd Ci Ci	2 Circular 1F Cd Cd+ Ci Ci	3 Half-Circ Cd Cd Ci Ci+	4 Tufted Cd Cd+ Ci Ci+	5 Crest-bred Cd Cd Ci+ Ci+	6 Crest-bred Cd Cd+Ci+ Ci+	7 Crest-bred Cd+ Cd+ Ci Ci	8 Crest-bred Cd+ Cd+ Ci Ci+	9 Normal Cd+Cd+Ci+ Ci+.

Like its predecessor, comparison with actual breeding results also revealed some significant anomalies. C. Warner suggested the possibility of linkage between the two genes creating a Tufted Type I and Tufted Type II. This modification helped with some Tufted anomalies but could not explain the more serious anomalies

relating to excessive percentages of Crested progeny from many matings, especially Crested x Normal matings. Despite its faults this theory has remained in vogue for several decades.

The term "Crestbred" related to any bird containing crest gene/s without having a visual crest. Such birds are indistinguishable from pure Normals containing no crest genes. Breeders have compromised by restricting the practical definition of a "Crestbred" to any non-crested bird having at least one visual Crested parent. Thus we have two definitions for "Crestbred", one a pure genetic definition based on genotype and a second based on practical breeding methods. The two definitions overlap significantly but are not identical.

In 2002 Ken Yorke published an article[14] documenting his more than 20 years of breeding the Australian strain of Crests involving approximately 400 Crest related progeny. This comprehensive evidence based article contributed much to our knowledge of Crests. The subjects covered included among others:

- Breeding results showing that birds with very weak feather disturbances including single feathers and temporary Crests have similar breeding potential to Tufteds,
- Evidence refuting the argument that the Crest gene is lethal,
- Confirmation that contrary to predictions of the Initiator theory, Crest x Normal matings may produce as few as 10% visual Crests,
- An opinion that a partially dominant Crest gene assisted by one or more other genes is the likely root cause of the feather swirl mechanism producing all Crest forms, thus creating a polygenic variety,
- An opinion that 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),

In 2004 George Clarke commenced an extensive desktop Crest Research Study. The Study utilised detailed breeding records for the period since 1980 provided primarily by fellow CBCA members Rob Hugo, Ken Yorke, and Jacky Jansen. Also included in the Study were a number of summarised UK breeding results reported in the CBCUK Handbook [15], and summary UK results reported by A F Fullilove in a 1970 article in Cage & Aviary Birds. [10] The aggregated breeding results from all these sources include a total of 3389 progeny and are summarised in Tables 2.1 and 2.2

These tables form an excellent resource for both future study and more importantly, provide some guidance as to the expected progeny from Crested matings, in the absence of a more accurate genetic theory.

THE CREST RESEARCH STUDY
AGGREGATED BREEDING RESULTS

Table 2.1

Mating	Number of Progeny					
	Total	CB	T	HC	FC	M
FC x FC	32	12	6	4	10	0
FC x HC	52	24	10	9	9	0
HC x HC	46	17	10	7	12	0
FC x T	219	75	61	26	56	1
HC x T	198	76	45	29	39	9
T x T	472	246	147	32	44	3
FC x CB	174	96	40	15	19	4
HC x CB	369	239	74	30	26	0
T x CB	894	643	167	41	38	5
CB x CB	53	46	6	0	1	0
FC x N	82	63	16	1	2	0
HC x N	225	200	23	2	0	0
T x N	504	430	63	10	1	0
CB x N	69	68	1	0	0	0

Table 2.2

Mating	Percentage of Progeny					
	Visual	CB	T	HC	FC	M
FC x FC	63%	38%	19%	13%	31%	0%
FC x HC	54%	46%	19%	17%	17%	0%
HC x HC	63%	37%	22%	15%	26%	0%
FC x T	66%	34%	28%	12%	26%	0.5%
HC x T	62%	38%	23%	15%	20%	5%
T x T	48%	52%	31%	7%	9%	0.6%
FC x CB	45%	55%	23%	9%	11%	2.3%
HC x CB	35%	65%	20%	8%	7%	0%
T x CB	28%	72%	19%	4.6%	4.3%	0.6%
CB x CB	13%	87%	11%	0%	1.9%	0%
FC x N	23%	77%	20%	1.2%	2.4%	0%
HC x N	11%	89%	10%	0.9%	0%	0%
T x N	15%	85%	13%	2%	0.2%	0%
CB x N	1%	99%	1%	0%	0%	0%

(Notes for Tables 2.1 & 2.2:- Temporary crests, weak feather disturbances, and Tufteds are grouped together. "M" = Multi-Crest)

Between 2004 and 2011 George Clarke published various iterations of a fundamentally different Crest theory based on the concepts of penetrance and expressivity. He named this the **PE Theory**[1-6, 20]. This theory proposed a single dominant Crest gene with 100% penetrance in the double factor state and only 20% penetrance in the single factor state. In short, all double factors show a visible crest of some type and only 20% of single factors show a visible crest. The remaining 80% of single factor birds that do not show a visible crest are in fact Crestbred. Penetrance is an observed statistical model used in genetic studies in all species to describe complex or unknown genetic mechanisms which result in gene/s not always expressing their characteristics visually. (An example in humans is, not all people who have a gene for a type of cancer actually get the disease, only a percentage will get the disease.) Environmental, biological or genetic factors are generally regarded as causes of reduced penetrance.

The PE theory uses the terms Crestbred (single factor) for a bird definitely containing one crest gene. It uses the term Crestbred (zero factor) for a bird definitely containing no crest genes, (but had at least one Crested parent). The penetrance aspects of the PE Theory produce a reasonable match to real breeding statistics, when taken on average, at predicting the quantity of visual Cresteds but cannot predict the type of crest.

To address prediction of the type of crest the concept of expressivity was introduced. Expressivity is an observed statistical model used to describe complex or unknown genetic mechanisms which result from a single genotype having multiple phenotypes. For example, a single factor Crested being either Full Circular, Half Circular or Tufted (or even Crestbred). George derived a number of expressivity equations and rules based on examination of real breeding statistics. Table 3 represents a summary of the mating expectations from the PE Theory including both penetrance and expressivity aspects.

The penetrance aspects of the PE Theory produce a reasonably useful statistical model for presence or absence of crested progeny from matings taken on average (i.e. the %Visual). The prediction of the type of crest (i.e. %Tuft, %HC, %FC) based on expressivity, still has some anomalies.

Table 3 PE Theory Matings and Expectations

Mating Group	Pairing Type	Progeny Genotypes				Progeny Phenotypes												
		Crest		Crestbred			CB		T		HC		FC		Tot	Tot	Tot	Tot
		% DF	% SF	% SF	% ZF	% Vis	% SF	% ZF	% DF	% SF	% DF	% SF	% DF	% SF	% CB	% Tuft	% HC	% FC
Crest x Crest	DF x DF	100	0	0	0	100	0	0	32	0	24	0	45	0	**0**	**32**	**24**	**45**
	DF x SF	50	10	40	0	60	40	0	16	8	12	1	22	1	**40**	**24**	**13**	**23**
	SF x SF	25	10	40	25	35	40	25	8	8	6	1	11	1	**65**	**16**	**7**	**12**
Crest x Crest-bred	DF x SFCB	50	10	40	0	60	40	0	16	8	12	1	22	1	**40**	**24**	**13**	**23**
	SF x SFCB	25	10	40	25	35	40	25	8	8	6	1	11	1	**65**	**16**	**7**	**12**
	DF x ZFCB	0	20	80	0	20	80	0	0	16	0	3	0	1	**80**	**16**	**3**	**1**
	SF x ZFCB	0	10	40	50	10	40	50	0	8	0	1	0	1	**90**	**8**	**1**	**1**
Crest x Normal	DF x N	0	20	80	0	20	80	0	0	16	0	3	0	1	**80**	**16**	**3**	**1**
	SF x N	0	10	40	50	10	40	50	0	8	0	1	0	1	**90**	**8**	**1**	**1**
Crest-bred x Crest-bred	SF x SF	25	10	40	25	35	40	25	8	8	6	1	11	1	**65**	**16**	**7**	**12**
	SF x ZF	0	10	40	50	10	40	50	0	8	0	1	0	1	**90**	**8**	**1**	**1**
	ZF x ZF	0	0	0	100	0	0	100	0	0	0	0	0	0	**100**	**0**	**0**	**0**
Crest-bred x Normal	SF x N	0	10	40	50	10	40	50	0	8	0	1	0	1	**90**	**8**	**1**	**1**
	ZF x N	0	0	0	100	0	0	100	0	0	0	0	0	0	**100**	**0**	**0**	**0**

In 2011 Don Burke published an article, "Crested Budgerigars - A New Whorled View"[18] in which he drew parallels between crested feather swirls and hair whorls in mammals and their potential effects in both wild birds and Crested budgerigars. He further commented on more modern genetic knowledge regarding tandem repeat DNA and epigenetics and how these and other genetic and biological systems may modify many budgerigar characteristics including feather "whorls" in Crested budgerigars.

Quoting from Don's article:-

> *"Firstly, it is clear to me now that what we call crested budgies aren't crested at all. They exhibit feather whorls, which are common all over mammals (hair whorls) and on the heads of some wild bird species. Whorls are mechanisms to radiate the angles of feather or hair growth to allow for changes in shape or angles of the animal itself. We all have a whorl on the back of our heads. This permits the hair to grow forward, backward and to both sides. If you didn't have the whorl, the hair on the back of your head and neck would grow upwards! Humans also have hair whorls on their backs, chests etc (more visible in hairy males).*

In mammals, hair whorls allow the coat to lay flat on the animal and also to shed water when the coat is wet.

In birds, feather whorls exist overwhelmingly for streamlining so that the bird can fly fast. Whorls also act to shed rainwater.

Thus a bird with a whorl on its head like a crested budgie is more likely to fly more slowly and thus be eaten by a hawk than non-crested budgies.

But not quite. A number of wild parrot species ARE crested. They have feather whorls just on the middle of the dip in the cere. Only about 60% of the whorl is visible since the other 40% is cere. The whorl helps to shape the feathers to grow up plus to the left and right on the forehead.....

We can strongly suggest that in birds:

1. Whorls or lack of them must be under strong genetic control to prevent disasters of poor aerodynamic design.

2. A locking mechanism – to prevent weird whorls – is very likely. That is, a genetic system to shut down whorl genes should they occur. A genetic insurance policy if you like.

3. An area mechanism is essential. That is, a genetic system which locates and pins down exactly where whorls occur is essential.....

<u>So What Can We Put Forward as a Theoretical Basis for Whorls?</u>

At least one gene exists for whorls in birds.

Whorls of hair or feathers occur during the embryological development of babies. Feather, skin and hair colour work in the same way. Whilst there is genetic control to the extent and location of, say, pied areas on a pied, much of it appears to be due to epigenetic effects. That is, a change in the appearance of a pied caused by genetic mechanisms other than changes in DNA sequences. Epigenetic effects nonetheless are Hereditary. This is in my view (shared by scientists), the mechanism behind variable whorl breeding results. What this means is that non-whorled babies that carry the whorl gene (or genes) that fail to show a visual whorl, may be unlikely to breed many or any whorled babies themselves. The lack of a visual whorl is likely to be hereditary.

For instance, when scientists raised 15 or 20 cloned Friesian cows, the white markings were different on all of them. Even though they were all genetically identical! Equally, identical human twins often have different hair whorls on their heads. Sometimes the whorls are clockwise in one and anticlockwise in the other. Sometimes one twin has two whorls and the other only one. To repeat, these patterns can be hereditary.

The only study I can find of multiple whorls is on mice. Curiously, the gene called Frizzled 6 causes hair whorls on mice in the following areas: on the head, on the feet and on both sides of the chest. That is, the basic whorl gene can cause whorls anywhere and often multiple areas on the one animal. Thus all of the whorls seen in birds may be due to one basic gene, with some other causes producing different areas of whorl development. Whorls in budgies on the back, chest or multiple head crests are all probably due to the same gene.

The cause of these other areas (chest, back, etc) is likely to be hereditary, but is not necessarily a gene as we know it.

Volume Controls

The new work on genetic volume controls (tandem repeats, etc) is, without doubt, part of the equation too. These volume controls direct just how much effect a gene has. From very pale dilutes, for example, to very dark dilutes. Volume controls have replaced the old furphy of modifier genes (another vague phrase!). A volume control may turn a half-circular whorl into a full-circular one, for all that we know. Volume controls too, are hereditary, even though they are not genes."

Some of these concepts have since stimulated further research by others. Don continues to investigate the aspect of whorls and gene regulators as applied to all birds and Crested budgerigars in particular.

The idea that a gene can somehow be "strengthened" or "weakened" may seem a little odd to most budgerigar breeders, and yet Crested breeders frequently use these expressions. It is a common warning that if Crest x Normal matings are made too frequently, the strength of the crest expression will be progressively degraded and Cresteds will cease to appear in the progeny. On the other hand the mating Crested x Crested together with careful selection can strengthen the crest expression in progeny, particularly if repeated sequentially.

Whether we think of crest expression as being caused by other expressivity genes, changes in the number of tandem repeats or gene regulators, it is not difficult to see how crest expression can be strengthened through consecutive Crested x Crested matings combined with rigorous selection. Similarly repeated Crested x Normal matings progressively dilute these same factors causing weakening of crest expression.

Since the introduction of UK Cresteds back into Australia in the 90's there has been an increase in the frequency of Multi-Crest forms in progeny. This can also be interpreted as evidence of a "stronger" gene being introduced via these imports. Ken Yorke described the impact of a single UK crest on his Australian Crest stud. [14][19]

In 2014 Ken Yorke published another major article, "Crested Genetics, Old Theories, New Ideas, Better Predictions?"[19] Using some 1930s research into hair whorls in swine as a starting point and noticing some similarities between that and the Initiator Theory he devised a new theory based on two dominant complementary genes (S_1 and S_2) which control the number of swirled feathers and a recessive gene (L_S) which controls the creation and location of a locus point required for a feather swirl to form.

This new theory also included the action of modifiers on these three genes which, when taken as a whole, explained the variation in the number of swirled feathers in various crests, the appearance of temporary crests, Multi-Crests, absent crests and also Frilled and Helicopter types. It also explained the majority of discrepancies in the Initiator Theory including its overestimation of percentages of phenotypes in many matings. It also provided a starting point for more detailed future study of the genotypes of Frilled, Helicopter and Pharaoh budgerigars.

For the purpose of genetic prediction the old categories of Tufted, Half Circular and Full Circular were dispensed with and replaced with Low, Medium and High Crests. Quoting from Ken Yorke's article:-

> *The visual Cresteds have the following genotypes:- $S_1S_{1+}S_2S_{2+}$, $S_1S_{1+}S_2S_2$, $S_1S_1S_2\ S_{2+}$, $S_1S_1S_2S_2$. These genotypes have two, three, three and four swirl genes respectively. I propose to call the first one "Low_{12} Crest" the next two, "$Medium_{122}$ Crest", "$Medium_{112}$ Crest" and the last "$High_{1122}$ Crest" (The subscripts in the names refer to which and how many S_1 and S_2 genes the types have).The higher the order of the crest the more swirl genes it has AND the more individual feathers form the crest feather swirl.*

As a starting point, the Low_{12} Crest category has the lowest number of swirled feathers and certainly includes tufts, "disappearing" (or temporary) crests and stray feathers around the eye and perhaps weak half circulars. At the other end of the scale the $High_{1122}$ Crest category has the highest number of swirled feathers and contain very strong crests (predominantly, if not exclusively, strong full circular crests).

Both types of Medium Crest contain all the other visual crest types with a medium number of swirled feathers (e.g. probably strong half circulars, weaker full circulars and perhaps even extremely strong tufts). At this stage I do not propose any obvious visual difference between the two Medium Crest types. There are no strict visual demarcation lines between each category as it is based solely on the number of swirled feathers, no matter where they are located or what they look like.....

Based on real breeding statistics, it is likely that a small percentage (approximately 20%) of the Crestbred no.s 10-13 may in fact show a swirl or disappearing swirl. Even though they only have one L_S gene it may be similar to the way that some Normals split Danish Recessive Pied show a visible head spot....

If you know the exact genotype of the parents Table 4 will give exact genotypes for the progeny and the exact percentages of each..... Due to the action of modifiers on the S_1, S_2 genes there will be some plus and minus tolerance on the physical appearance for each progeny type and thus an apparent tolerance on the percentages of each visual type. Due to the action of modifiers on the L_S ..... genes there may be multi-swirls or absent swirls of each visual type which again apply a tolerance on the physical appearance. All these tolerances can vary over time. It's like trying to predict a moving target. The approximate maximum percentage of progeny with visible swirls quoted in Table 4 matings will be reduced by those modifiers causing absent swirls. [19]

Table 4 - List of Crest Related Genotypes and Matings

TYPE NAME GENOTYPE	PHENOTYPE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1. High$_{1122}$Crest $S_1S_1S_2S_2L_5L_5$	Skull swirl with high number of feathers	100% - 1 100%																										
2. Med$_{122}$Crest $S_1S_1\text{-}S_2S_2L_5L_5$	Skull swirl with medium number of feathers	50% - 1,2 100%	50% - 2, 25% - 1,7 75%																									
3. Med$_{112}$Crest $S_1S_1S_2S_2\text{-}L_5L_5$	Skull swirl with medium number of feathers	50% - 1,3 100%	25% - 1,2,3,4 100%	50% - 3, 25% - 1,5 75%																								
4. Low$_{12}$Crest $S_1S_1\text{-}S_2S_2\text{-}L_5L_5$	Skull swirl with low number of feathers	25% - 1,2,3,4 100%	25% - 2,4, 12.5% - 1,3,7,8 75%	25% - 3,4, 12.5% - 1,2,5,6 75%	25% - 4, 12.5% - 2,3,6,8, 6.25% - 1,5,7,9 56.25%																							
5. Crestbred$_{11SS}$ $S_1S_1S_2\text{-}S_2\text{-}L_5L_5$	Normal	100% - 3 100%	50% - 3,4 100%	50% - 3,5 50%	25% - 3,4,5,6 50%	100% - 5 0%																						
6. Crestbred$_{1SS}$ $S_1S_1\text{-}S_2\text{-}S_2\text{-}L_5L_5$	Normal	50% - 3,4 100%	50% - 4, 25% - 3,8 75%	25% - 3,4,5,6 50%	25% - 4,6, 12.5% - 3,5,8,9 37.5%	50% - 5,6 0%	50% - 6, 25% - 5,9 0%																					
7. Crestbred$_{22SS}$ $S_1\text{-}S_1\text{-}S_2S_2L_5L_5$	Normal	100% - 2 100%	50% - 2,7 50%	50% - 2,4 100%	25% - 2,4,7,8, 50%	100% - 4 100%	50% - 4,8 50%	100% - 7 0%																				
8. Crestbred$_{2SS}$ $S_1\text{-}S_1\text{-}S_2S_2\text{-}L_5L_5$	Normal	50% - 2,4 100%	25% - 2,4,7,8 50%	50% - 4, 25% - 2,6 75%	25% - 4,8, 12.5% - 2,6,7,9 37.5%	50% - 4,6 50%	25% - 4,6,8,9 25%	50% - 7,8 0%	50% - 8, 25% - 7,9 0%																			
9. Normal$_{SS}$ $S_1\text{-}S_1\text{-}S_2\text{-}S_2\text{-}L_5L_5$	Normal	100% - 4 100%	50% - 4,8 50%	50% - 4,6 50%	25% - 4,6,8,9 50%	100% - 6 0%	50% - 6,9 0%	100% - 8 0%	50% - 8,9 0%	100% - 9 0%																		
10. Crestbred$_{1122S}$ $S_1S_1S_2S_2L_5L_-$	Normal (small % may have a swirl)	50% - 1,10 60%	25% - 1,2,10,11 60%	25% - 1,3,10,12 60%	12.5% - 1,2,3,4 ,10,11,12,13 60%	50% - 3,12 60%	25% - 3,4,12,13 60%	50% - 2,11 60%	25% - 2,4,11,13 60%	50% - 4,13 60%	25% - 1,19 50% - 10 35%																	
11. Crestbred$_{122S}$ $S_1S_1\text{-}S_2S_2L_5L_-$	Normal (small % may have a swirl)	25% - 1,2,10,11 60%	25% - 2,11 12.5% - 1,7,10,16 45%	12.5% - 1,2,3,4, 10,11,12,13 60%	12.5% - 2,4,11,13 6.25% - 1,3,7,8, 10,12,16,17 45%	25% - 3,4,12,13 60%	25% - 4,13 12.5% - 3,8,12,17 45%	25% - 2,7,11,16 30%	12.5% - 2,4,7,8, 11,13,16,17 30%	25% - 4,8,13,17 30%	12.5% - 1,2,19,20 25% - 10,11 35%	12.5% - 2,10,16,20 6.25% - 1,7,19,25 25% - 11 26.25%																
12. Crestbred$_{112S}$ $S_1S_1S_2\text{-}S_2\text{-}L_5L_-$	Normal (small % may have a swirl)	25% - 1,3,10,12 60%	12.5% - 1,2,3,4, 10,11,12,13 60%	25% - 3,12 12.5% - 1,5,10,14 45%	12.5% - 3,4,12,13 6.25% - 1,2,5,6,10 ,11,14,15 45%	25% - 3,5,12,14 30%	12.5% - 3,4,5,6, 12,13,14,15 30%	25% - 2,4,9,13 60%	25% - 4,13 12.5% - 2,6,11,15 45%	25% - 4,6,13,15 30%	12.5% - 1,3,19,21 25% - 10,12 35%	12.5% - 10,11,12,13 6.25% - 1,2,3,4 ,19,20,21,22 35%	12.5% - 3,10,14,21 6.25% - 1,5,19,23 25% - 12 21.25%														
13. Crestbred$_{12S}$ $S_1S_1\text{-}S_2S_2\text{-}L_5L_-$	Normal (small % may have a swirl)	12.5% - 1,2,3,4, 10,11,12,13 60%	12.5% - 2,4,11,13 6.25% - 1,3,7,8, 10,12,16,17 45%	12.5% - 3,4,12,13 6.25% - 1,2,5,6, 10,11,14,15 45%	12.5% - 4,13 6.25% - 2,3,6,8, 11,12,15,17, 3.125% - 1,5,7,9 ,10,14,16,18 33.75%	12.5% - 3,4,5,6 ,12,13,14,15 30%	12.5% - 4,6,13,15 6.25% - 3,5,8,9 ,12,14,17,18 22.5%	12.5% - 2,4,7,8, 11,13,16,17 30%	12.5% - 4,8,13,17 6.25% - 2,6,7,9, 11,15,16,18 22.5%	12.5% - 4,6,8,9, 13,15,17,18 15%	6.25% - 1,2,3,4, 19,20,21,22 12.5% - 10,11,12,13 35%	12.5% - 11,13 6.25% - 2,4,10,12, 16,17,20,22 3.13% - 1,3,7,8 ,19,21,25,26 26.25%	12.5% - 12,13 6.25% - 3,4,10,11, 14,15,21,22 3.13% - 1,2,5,6, 19,20,23,24 26.25%	12.5% - 13 6.25% - 4,11,12,15,17,22 3.13% - 2,3,6,8, 10,14,16,18,20,21,24,26 1.56% - 1,5,7,9,19,23,25,27 19.7%														
14. Crestbred$_{11S}$ $S_1S_1S_2\text{-}S_2\text{-}L_5L_-$	Normal	50% - 3,12 60%	25% - 3,4,12,13 60%	25% - 3,5,12,14 30%	12.5% - 3,4,5,6, 12,13,14,15 30%	50% - 5,14 0%	25% - 5,6,14,15 0%	50% - 4,13 60%	25% - 4,6,13,15 30%	50% - 6,15 0%	25% - 3,21 50% - 12 35%	12.5% - 12,13,14,15 6.25% - 3,4,5,6, 19,20,21,22 17.5%	12.5% - 3,5,21,23 25% - 12,14 17.5%	6.25% - 3,4,5,6,21,22,23,24 12.5% - 12,13,14,15 17.5%	50% - 14, 25% - 5,23 0%													
15. Crestbred$_{1S}$ $S_1S_1\text{-}S_2\text{-}S_2\text{-}L_5L_-$	Normal	25% - 3,4,12,13 60%	25% - 4,13 12.5% - 3,8,12,17 45%	12.5% - 3,4,5,6, 12,13,14,15 30%	12.5% - 4,6,13,15 6.25% - 3,5,8,9, 12,14,17,18 22.5%	25% - 5,6,14,15 0%	25% - 6,15 12.5% - 5,9,14,18 0%	25% - 4,8,13,17 30%	12.5% - 4,6,8,9 ,13,15,17,18 15%	25% - 6,9,15,18 0%	12.5% - 3,4,21,22 25% - 12,13 35%	12.5% - 13,15 6.25% - 4,6,12,14, 17,18,22,24 3.13% - 3,5,8,9, 21,23,26,27 13.13%	6.25% - 3,4,5,6, 21,22,23,24 12.5% - 12,13,14,15 17.5%	12.5% - 13,15 6.25% - 4,6,12,14, 17,18,22,24 3.13% - 3,5,8,9,21,23,26,27 13.13%	12.5% - 5,6,23,24 25% - 14,15 0%	12.5% - 6,14,18,24 25% - 15 6.25% - 5,9,23,27 0%												
16. Crestbred$_{22S}$ $S_1\text{-}S_1\text{-}S_2S_2L_5L_-$	Normal	50% - 2,11 60%	25% - 2,7,11,16 30%	25% - 2,4,11,13 30%	12.5% - 2,4,7,8, 11,13,16,17 30%	50% - 4,13 60%	25% - 4,8, 13,17 30%	50% - 7,16 0%	25% - 7,8,16,17 0%	50% - 8,17 0%	25% - 2,20 50% - 11 35%	12.5% - 11,13,16,17 6.25% - 2,4,7,8, 20,22,25,26 17.5%	12.5% - 2,4,20,22 25% - 11,13 35%	6.25% - 2,4,7,8,20,22,25,26 12.5% - 11,13,16,17 17.5%	50% - 13, 25% - 4,22 30%	25% - 13,17 12.5% - 4,8,22,26 17.5%	25% - 7,25 50% - 16 0%											
17. Crestbred$_{2S}$ $S_1\text{-}S_1\text{-}S_2S_2\text{-}L_5L_-$	Normal	25% - 2,4,11,13 60%	12.5% - 2,4,7,8, 11,13,16,17 30%	25% - 4,13 12.5% - 2,6,11,15 45%	12.5% - 4,8,13,17 6.25% - 2,6,7,9, 11,15,16,18 22.5%	25% - 4,6,13,15 30%	12.5% - 4,6,8,9, 13,15,17,18 13%	25% - 7,8,16,17 0%	25% - 8,17 12.5% - 7,9,16,18 0%	25% - 8,9,17,18 0%	12.5% - 2,4,20,22 25% - 11,13 35%	6.25% - 2,4,7,8, 20,22,25,26 12.5% - 11,13,16,17 17.5%	12.5% - 4,11,15,22 6.25% - 2,6,20,24 25% - 13 26.25%	12.5% - 13,17 6.25% - 4,8,11,15, 16,18,22,26 3.13% - 2,6,7,9,20,24,25,27 13.13%	12.5% - 4,6,22,24 25% - 13,15 17.5%	6.25% - 4,6,8,9 ,22,24,26,27 12.5% - 13,15,17,18 8.75%	25% - 16,17 12.5% - 7,8,25,26 0%	12.5% - 8,16,18,26 6.25% - 7,9,25,27 25% - 17 0%										
18. Normal$_{S}$ $S_1\text{-}S_1\text{-}S_2\text{-}S_2\text{-}L_5L_-$	Normal	50% - 4,13 60%	25% - 4,8,13,17 30%	25% - 4,6,13,15 30%	12.5% - 4,6,8,9, 13,15,17,18 15%	50% - 6,15 0%	25% - 6,9,15,18 0%	50% - 8,17 0%	25% - 8,9,17,18 0%	50% - 9,18 0%	25% - 4,22 50% - 13 35%	12.5% - 13,15,17,18 6.25% - 4,6,8,9 ,22,24,26,27 8.75%	12.5% - 4,6,22,24 25% - 13,15 17.5%	6.25% - 4,6,8,9,22,24,26,27 12.5% - 13,15,17,18 8.75%	50% - 15, 25% - 6,24 0%	12.5% - 6,9,24,27 25% - 15,18 0%	50% - 17, 25% - 8,26 0%	12.5% - 8,9,26,27 25% - 17,18 0%	50% - 18, 25% - 9,27 0%									
19. Crestbred$_{1122}$ $S_1S_1S_2S_2L_-L_-$	Normal	100% - 10 20%	50% - 10,11 20%	50% - 10,12 20%	25% - 10,11,12,13 30%	100% - 12 20%	50% - 12,13 20%	100% - 11 20%	50% - 11,13 20%	100% - 13 20%	50% - 10,19 10%	25% - 10,11,19,20 10%	25% - 10,12,19,21 10%	12.5% - 10,11,12,13, 19,20,21,22 10%	50% - 12,21 10%	25% - 12,13,21,22 10%	50% - 11,20 10%	25% - 11,13,20,22 10%	50% - 13,22 10%	100% - 19 0%								
20. Crestbred$_{122}$ $S_1S_1S_2S_2L_-L_-$	Normal	50% - 10,11 20%	50% - 11 25% - 10,16 15%	25% - 10,11,12,13 20%	25% - 11,13 12.5% - 10,12,16,17 15%	50% - 12,13 20%	50% - 13 25% - 12,17 15%	50% - 11,16 10%	25% - 11,13,16,17 10%	50% - 13,17 10%	25% - 10,11,19,20 10%	12.5% - 10,16,19,25 25% - 11,20 7.5%	12.5% - 10,11,12,13, 19,20,21,22 10%	12.5% - 11,13,20,22 6.25% - 10,12,16,17, 19,21,25,26 7.5%	25% - 12,13,21,22 10%	25% - 13,22 12.5% - 12,17,21,26 7.5%	25% - 11,16,20,25 5%	12.5% - 11,13,16,17, 20,22,25,26 5%	25% - 13,17,22,26 5%	50% - 19,20 0%	50% - 20, 25% - 19,25 0%							
21. Crestbred$_{112}$ $S_1S_1S_2\ S_2\text{-}L_-L_-$	Normal	50% - 10,12 20%	25% - 10,11,12,13 20%	50% - 12 25% - 10,14 15%	25% - 12,13 12.5% - 10,11,14,15 15%	50% - 12,14 10%	25% - 12,13,14,15 10%	50% - 9,13 10%	50% - 13 25% - 11,15 15%	50% - 13,15 10%	25% - 10,12,19,21 10%	12.5% - 10,11,12,13 ,19,20,21,22 10%	12.5% - 10,14,19,23 25% - 12,21 7.5%	12.5% - 12,13,21,22 6.25% - 10,11,14,15, 19,20,23,24 7.5%	25% - 12,14,21,23 5%	12.5% - 12,13,14,15, 21,22,23,24 5%	25% - 11,13,20,22 10%	25% - 13,22 12.5% - 11,15,20,24 7.5%	25% - 13,15,22,24 5%	50% - 19,21 0%	25% - 19,20,21,22 0%	50% - 21, 25% - 19,23 0%						
22. Crestbred$_{12}$ $S_1S_1\text{-}S_2S_2\text{-}L_-L_-$	Normal	25% - 10,11,12,13 20%	25% - 11,13 12.5% - 10,12,16,17 15%	25% - 12,13 12.5% - 10,11,14,15 15%	25% - 13 12.5% - 11,12,15,17, 6.25% - 10,14,16,18 11.25%	25% - 12,13,14,15 10%	25% - 13,15 12.5% - 12,14,17,18 7.5%	25% - 11,13,16,17 10%	25% - 13,17 12.5% - 11,15,16,18 5%	25% - 13,15,17,18 5%	12.5% - 10,11,12,13, 19,20,21,22 10%	12.5% - 11,13,20,22 6.25% - 10,12,16,17, 19,21,25,26 7.5%	12.5% - 12,13,21,22 6.25% - 10,11,14,15, 19,20,23,24 7.5%	12.5% - 13,22 6.25% - 11,12,15,17, 20,21,24,26 3.13% - 10,14,16,18, 19,23,25,27 5.6%	12.5% - 12,13,14,15, 21,22,23,24 5%	12.5% - 13,15,22,24 6.25% - 12,14,17,18, 21,23,26,27 3.75%	12.5% - 11,13,16,17, 20,22,25,26 5%	12.5% - 13,17,22,26 6.25% - 11,15,16,18, 20,24,25,27 3.75%	12.5% - 13,15,17, 18,22,24,26,27 2.5%	25% - 19,20, 21,22 0%	25% - 20,22, 12.5% - 19,21,25,26 0%	25% - 21,22, 12.5% - 19,20,23,24 0%	25% - 22, 12.5% - 20,21,24,26, 6.25% - 1,5,7,9 0%					
23. Crestbred$_{11}$ $S_1S_1S_2S_2\text{-}L_-L_-$	Normal	100% - 12 20%	50% - 12,13 20%	50% - 12,14 10%	25% - 12,13,14,15 10%	100% - 14 0%	50% - 14,15 0%	100% - 13 20%	50% - 13,15 10%	100% - 15 0%	50% - 12,21 10%	25% - 12,13,21,22 10%	25% - 12,14,21,23 5%	12.5% - 12,13,14,15, 21,22,23,24 5%	50% - 14,23 0%	25% - 14,15,23,24 0%	50% - 13,22 10%	25% - 13,15,22,24 5%	50% - 15,24 0%	100% - 21 0%	50% - 21,22 0%	50% - 21,23 0%	25% - 21,22,23,24 0%	100% - 23 0%				
24. Crestbred$_{1}$ $S_1S_1\text{-}S_2\text{-}S_2\text{-}L_-L_-$	Normal	50% - 12,13 20%	50% - 13 25% - 12,17 15%	25% - 12,13,14,15 10%	25% - 13,15 12.5% - 12,14,17,18 7.5%	50% - 14,15 0%	50% - 15 25% - 14,18 0%	50% - 13,17 10%	25% - 13,15,17,18 5%	50% - 15,18 0%	25% - 12,13,21,22 10%	25% - 13,22 12.5% - 12,17,21,26 7.5%	12.5% - 12,13,14,15, 21,22,23,24 5%	12.5% - 13,15,22,24 6.25% - 12,14,17,18, 21,23,26,27 3.75%	25% - 14,15,23,24 0%	25% - 15,24 12.5% - 14,18,23,27 0%	25% - 13,17,22,26 5%	12.5% - 13,15,17,18, 21,24,26,27 5%	25% - 15,18,24,27 0%	50% - 21,22 0%	50% - 22, 25% - 21,26 0%	25% - 21,22,23,24 0%	25% - 22,24, 12.5% - 21,23,26,27 0%	50% - 23,24 0%	50% - 24, 25% - 23,27 0%			
25. Crestbred$_{22}$ $S_1\text{-}S_1\text{-}S_2S_2L_-L_-$	Normal	100% - 11 20%	50% - 11,16 10%	50% - 11,13 10%	25% - 11,13,16,17 10%	100% - 13 20%	50% - 13,17 10%	100% - 16 0%	50% - 16,17 0%	100% - 17 0%	50% - 11,20 10%	25% - 11,16,20,25 5%	25% - 11,13,20,22 10%	12.5% - 11,13,16,17, 20,22,25,26 5%	50% - 13,22 10%	25% - 13,17,22,26 5%	50% - 16,25 0%	25% - 16,17,25,26 0%	50% - 17,26 0%	100% - 20 0%	50% - 20,25 0%	50% - 20,22 0%	25% - 20,22,25,26, 0%	100% - 22 0%	50% - 22,26 0%	100% - 25 0%		
26. Crestbred$_{2}$ $S_1\text{-}S_1\text{-}S_2S_2\text{-}L_-L_-$	Normal	50% - 11,13 20%	25% - 11,13,16,17 10%	50% - 13 25% - 11,15 15%	25% - 13,17 12.5% - 11,15,16,18 7.5%	50% - 13,15 10%	25% - 13,15,17,18 5%	50% - 16,17 0%	50% - 17 12.5% - 7,9,16,18 0%	50% - 17,18 0%	25% - 11,13,20,22 10%	12.5% - 11,13,16,17, 20,22,25,26 5%	25% - 13,22 12.5% - 11,15,20,24 7.5%	25% - 13,17,22,26 6.25% - 11,15,16,18, 20,24,25,27 3.75%	25% - 13,15,22,24 5%	12.5% - 13,15,17,18, 22,24,26,27 2.5%	25% - 16,17,25,26 0%	25% - 16,18,25,27 0%	25% - 17,18,26,27 0%	50% - 20,22 0%	25% - 20,22,25,26 0%	50% - 22, 25% - 20,24 0%	25% - 22,26, 12.5% - 20,24,25,27 0%	50% - 22,24 0%	25% - 22,24, 26,27 0%	50% - 25,26 0%	50% - 26, 25% - 25,27 0%	
27. Normal (pure) $S_1\text{-}S_1\text{-}S_2\text{-}S_2\text{-}L_-L_-$	Normal	100% - 13 20%	50% - 13,17 10%	50% - 13,15 10%	25% - 13,15,17,18 5%	100% - 15 0%	50% - 15,18 0%	100% - 17 0%	50% - 17,18 0%	100% - 18 0%	50% - 13,22 10%	25% - 13,17,22,26 5%	25% - 13,15,22,24 5%	12.5% - 13,15,17,18, 22,24,26,27 2.5%	50% - 15,24 0%	25% - 15,18,24,27 0%	50% - 17,26 0%	25% - 17,18,26,27 0%	50% - 18,27 0%	100% - 22 0%	50% - 22,26 0%	50% - 22,24 0%	25% - 22,24,26,27 0%	100% - 24 0%	50% - 24,27 0%	100% - 26 0%	50% - 26,27 0%	100% - 27 0%
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27

Legend

% Progeny Types	
Approx Maximum % Progeny with Swirls	Includes Multi-Swirls and Temporary Swirls. Excludes Absent Swirls (reduction in value applies).

Not true breeding to type

Cresteds are not true breeding with respect to Crested type. Any Crested type can produce any other Crested type. It is a common belief that it is not possible to create a Crested strain that will produce only a single type of crest. [14][15]. However there is some evidence that when breeding from a very limited gene pool of Tufteds that have no recent Circular ancestry, it may be difficult to produce Circulars.

As part of George Clarke's Research Study, detailed breeding records showed clear examples of situations where progress towards a "higher" Crested type was blocked until an outcross in the form of a Crested or Crestbred with the necessary genes or genetic configurations was introduced. For example, breeding records show that Rob Hugo bred Tuft x Tuft for 8 years from 1981 without producing a single Circular. It is worth noting that in this particular instance the Tufts being used had no proven Circular ancestry.

Rob's results may represent a perfect example of Cyril Warner's suggestion of Type I and Type II Tufteds applied to the Initiator Theory (and can also be equally applied to Ken Yorke's theory). A Tufted Type I has the Cd and Ci genes on the same chromosome (S_1 and S_2 genes in the Yorke theory). A Tufted Type II has the Cd gene and Ci genes on opposite chromosomes. The relevant matings are:-

With linkage (excluding crossovers)

Tufted Type I x Tufted Type I
= 25% FC + 50% Tufted Type I + 25% Normal (i)
and
Tufted Type II x Tufted Type II
= 50% Tufted Type II + 50% Crestbred (ii)

Without linkage

Tufted x Tufted
= 18.75% FC + 12.5% HC + 25% Tufted + 37.5% Crestbred
+ 6.25% Normal (iii)

The matings (i) and (ii) above are shown without the effect of gene crossover for simplicity. Rob's matings represent all mating (ii) involving all Tufted Type II. Crossovers would occur and eventually a small percentage of FC, HC, Tufted Type I and Normals would appear from mating (ii), however the absence of this occurring in Rob's case suggests that the two genes may be very closely linked and hence a small crossover rate.

Alternatively, in a single gene theory the above example may highlight a lack of enhancing modifiers (e.g tandom repeat DNA, gene regulators etc) required to improve a Tufted up to a higher order crest or the presence of depressing modifiers preventing improvement.

All the above theories and ideas offered by Fox, Warner, Clarke, Burke and Yorke may or may not reflect the true underlying genetic and biological processes involved in creating the feather swirls required for the appearance of Crested budgerigars. They do nevertheless offer, at the very least, varying degrees of accuracy in modelling the outcomes of matings involving the Crested variety. The problem with all these theories, no matter how accurate, is that it is reasonably certain that there is no obvious one to one relationship between one genotype and one phenotype. In short, the breeder can never be completely certain of the genotype of any crest related parent bird and thus without a known genotype for the parents then accurate prediction of progeny from those particular parents is virtually impossible.

Using the above genetic theories as a basis only, other more practical and more general guidelines have been developed to assist Crested breeders in their selection and breeding programmes. These guidelines will be discussed in Chapter 5 "Breeding With Crested Budgerigars".

The Normal is gradually disappearing

Crested breeders retain some Crestbreds for breeding but many will be discarded and passed on knowingly or unknowingly, to other budgerigar breeders. Very soon the fact that these birds and their descendants may carry the Crested gene/s is forgotten. Many of the Crested genes themselves remain in the breeding pool and may be passed down invisibly through subsequent generations via unidentified Crestbreds.

Crested breeders can no longer be confident that "Normals" carry no Crested genes. For Crested researchers this means greater care and scrutiny will be required when assessing Crested x Normal breeding results. Ken Yorke [19] has studied breeding results from two different time periods in the UK and documented this very change in Table 5.

Table 5

Mating Summary	UK 1960s %Visual	UK 1980s %Visual
Visual x "Normal"	14%	29%

Lethality

In early attempts to explain the unusual Crested inheritance patterns, the idea that the Crested gene may be lethal when present as a Double Factor was floated. It is worth discussing this hypothesis because it occasionally still crops up in various places.

In a single gene theory (e.g. PE Theory), if DF's are all lethal, then all surviving Crests would be SF's and all Crest x Crest matings would be SF x SF.

This would produce 25% DF, 50% SF and 25% Normals. Since DF's would be lethal the viable progeny would become 67% Crest and 33% Normal. This is roughly the actual proportion found for Crest x Crest matings. Hence the attraction to the lethality hypothesis.

There are at least three problems with the hypothesis.

1. If 25% of Crested x Crested progeny (DF's) die, the number of progeny from these matings would be noticeably less than for Normal x Normal matings. Breeders from UK [10], Europe [7], and Australia [14] all report survivability in Crested matings equal to or better than for Non-Crested matings. Classens [7] and Yorke [14] both report a 20% increase in the hatch rate for Crested matings. See Table 6 below.

Table 6

Reference	**Non-Crest Matings**		**Crest Matings**	
	No of Eggs	**%Hatch**	**No of Eggs**	**%Hatch**
Classens [7]	1451	47%	775	56%
Yorke [14]	3941	39%	791	47%

2. Crested x Normal matings would all be SF x N, producing 50% Crested & 50% Crestbreds. This is a much higher %Cresteds than found in practice. (Average approx 15%).
3. Crestbred progeny would carry no Crested genes. In practice Crested x Crestbred matings produce many more Cresteds than Crested x Normal matings; hence some Crestbreds must carry Crested genes.

Thus the double factor lethality hypothesis alone is an unsatisfactory explanation of Crest inheritance patterns.

In a polygenic gene theory the percentage of non-viable offspring would be less than those of the single gene theory example above and thus harder to identify. It would likely only affect the following genotypes:-

a) Initiator Theory - Full Circle (DF)
b) Yorke Theory - $High_{1122}$Crest, $Crestbred_{1122S}$ and $Crestbred_{1122}$.

However, the survivability aspects mentioned in point 1from the single gene theory example above would still apply at the very least.

The main basis for the lethal issue arose from the 1963 Zisweiler thesis [12] and this has since been shown to be a scientifically flawed study. No other supporting evidence for lethal factors in Crested budgerigars has ever been found.

Chapter 5

BREEDING WITH CRESTED BUDGERIGARS

The Challenge

The Crested Budgerigar is often described as the "Ultimate Challenge". The challenge is to simultaneously achieve three different goals;

Goal **1**. -To improve the general exhibition and colour variety features;
Goal **2**. -To improve the quality of the crest characteristics;
Goal **3**. -To maximise the percentage of visual crest progeny;

When carrying out any breeding plan the breeder will be faced with difficult decisions in attempting to satisfy the three Goals. Improvement towards one goal will frequently compromise progress towards the other two.

In pursuit of these goals there is no magic prescriptive formula to follow, only guidelines and strategies. In common with other varieties there will be many different paths to success depending upon the initial breeding stock and progeny produced along the way. Breeders need to maintain a flexible approach and react appropriately depending upon the circumstances of the time. A few guidelines which can assist breeders achieve the goals are outlined below.

Goal 1. -to improve the general exhibition and colour variety features

Cresteds are no different to other varieties in this regard. General exhibition features (Size, Type etc) are polygenic (i.e. controlled by multiple genes) and/or influenced by gene modifiers/regulators. Colour variety features involve fewer, more readily manipulated genes. Budgerigar breeders have developed numerous strategies aimed at concentrating the desirable genes/modifiers and eliminating the undesirable genes/modifiers. These include in-breeding, line breeding, outcrossing, avoiding duplication of faults, ruthless selection, accurate record keeping etc, and are described in detail in standard budgerigar reference texts.

Goal 2. -to improve the quality of the crest characteristics

In general the same strategies apply as for goal 1. However Cresteds are not true breeding. Any Crested visual type can produce any other visual type. This fact presents the breeder with a real challenge and test for his skills.

The best guideline is to select at least one parent which is visually Crested and has the strongest possible crest feathering, i.e. the maximum number of swirled feathers. This more often than not is a Full Circular Crested. Such birds have some visible evidence to their potential with regard to Crested genes and modifiers.

Conversely, using visual Cresteds with a low number of swirled feathers offers a dilemma. Are such birds, enhanced modified versions of a lesser quality crest or depressed modified versions of a better quality crest.

When using Crestbreds, there is no visible indicator to the genetic potential of these birds. It is also true that many Crestbreds carry no useful crest genetic material.

Goal 3. -to maximise the percentage of visual crest progeny
This is an important goal for two reasons. Firstly it is necessary to ensure that sufficient numbers are available for selection of suitable pairings each year. If choice is too restricted, progress towards quality goals 1 and 2 can be expected to be slow.

Crested x Crested matings generally produce the most Crested. Using Normals dramatically reduces the number of Crested progeny.

Matings available to Crest Breeders

Crest x Crest mating.
This mating produces the highest proportion of Crested progeny (approx. 60%) and would be ideal if the other exhibition qualities of the parents were very good. Unfortunately this is generally not the case and continued repeated matings of this type can be expected to result in loss of size and other desirable exhibition qualities. This mating is helpful for achieving goals 2&3 but usually counterproductive for achieving goal No1.

Crest x Normal mating
This mating produces the lowest proportion of Crested progeny (approx. 15%) but must be used from time to time to improve size, quality and possibly fertility, usually at the expense of favourable Crest genes. This mating is helpful for achieving goal No1 but usually counterproductive to direct achievement of goals 2&3. However the mating works indirectly towards these goals through the production of large numbers of Crestbreds for use in Crested x Crestbred matings.

Crest x Crestbred mating
This mating produces a proportion of Cresteds intermediate between the previous two (approx 30%). In favourable circumstances it provides an opportunity to improve size and general exhibition features while improving the quality of the crest. To maximise the quantity of visual Cresteds, depending on the theoretical genetic theory involved (see Chapter 4), there may be some advantage to using Crestbreds which have two visually crested parents and a disadvantage using Crestbreds with a Normal parent.

Crestbred x Crestbred, and Crestbred x Normal Matings
These matings usually produce very low percentages of Crested progeny. The risk that one or both parents may not carry the Crested gene/s means the

matings are not well suited for inclusion in any breeding plan.

Crest Genes

In discussing the above matings it is necessary to stress the important issue of the number of Crested genes carried by the parents. Certainty in relation to this matter can be a powerful tool in the hands of the breeder. The number of Crested genes carried by the parents has enormous influence on the percentages and types of visual crest progeny, and the number of Crested genes carried by the progeny. All these aspects are vital when preparing breeding plans for the following year. Breeding plans will always be more effective if the breeder has knowledge of the number of parental Crested genes in a mating.

Irrespective of the theoretical genetic theory (see Chapter 4) the following are generally true;

- Matings that include a homozygous Crested parent are expected to produce the highest proportions of visual Cresteds.
- All visual Cresteds produced from a mating which includes a Normal have a reduced number of Crested genes.
- Any Visual Cresteds produced from the mating Crested x Normal tend to be lower order Cresteds (e.g Tufted, disappearing crests and stray feathers). This mating is not well suited for direct production of Full Circulars.

Identification of Crestbreds carrying crest genes.

Some Crestbreds do not carry Crested genes and these non-crest-gene-carrying Crestbreds produce the same low percentage of visual Crests as do Normals. The difficulty for breeders is that both types of Crestbreds are visually identical to Normals. The best clue to identification of Crestbreds genuinely carrying Crested genes comes from an examination of breeding results. Crestbreds that, when mated to a Crest, produce on average more than 30% visual Cresteds are most probably genuine Crestbreds. Those which produce on average less than 30% visuals are likely to be Normals carrying no crest gene. It is suggested that breeders attach an additional plastic ring to those Crestbreds they have identified as probable genuine ones.

Selection of Initial Stock

The following practical advice is provided from the CBCUK Handbook [15].

> *"The selection of the initial crested stock is critical. If the breeder wishes to exhibit, the birds should have strong crests of the desired type and to be of the best size and quality that can be obtained. Inferior specimens can be used, however, if the breeder is prepared to be more patient. As crests are not yet up to the same standards as the normal varieties, and there are fewer to choose from, the crested*

breeder cannot afford to be too fussy. Another point of importance is that crests should be assessed in the same manner as normal birds with regard to exhibition faults, such as a nipped neck, crossed wings, a drooping tail, a jutting beak and an imbalance on the perch. These exhibition faults will be hard to breed-out. Sometimes, it is easier to purchase a small but well-shaped Crest and to breed-in show qualities.

Although it is usually advocated that cocks should be used as a foundation stock hens can be just as good. However, there are two reasons as to why cocks are preferred to hens. Firstly, when breeding for a larger size, whereas a small crested cock can easily mount the large normal hen, the obverse is not true and there is a higher risk of infertile eggs. Secondly, a crested cock, with care and some general breeding knowledge, can be paired with more than one good quality normal hen in the same breeding season. Parents raising their own young readily foster crested chicks. If a chick is rejected by either its natural or foster parents, the crest is never the cause.

Ideally, the new breeder should first obtain two crested cocks of the highest quality from two unrelated strains. Each cock should then be paired with good quality normal hens to produce the second generation. The two strains can then be inter-bred for quality using Crest x Crestbred pairings. In the third generation, if any quality such as amount of back-skull, width of head or depth of mask needs improvement, then suitable normal birds should be mated with the best crested bird of the stock. Hopefully, by the fifth generation the improved qualities will start to appear in the crested birds.

Crested budgerigars can be bred in all colours and colour combinations; such varieties as crested, golden faced, rainbows and tri-coloured pieds are very attractive. Obviously, Crests in the normal colours, greens and blues in all three shades plus greys and grey-greens offer the best chances of producing birds for show purposes as they do for normals. However, Crests show best on Australian Pieds and Dutch Clear-Flights where the dominant genes of these do not overly restrict their size. Sex-linked characters like opaline, cinnamon and even lutino and albino have presented some good crested birds for exhibition. The yellow-face blue type of birds lends itself very well to the crested character, (unlike the birds in the green series) because the feather barbules near the quill are white and thus the crest is in two colours:- yellow around the edge and white in the centre. This is especially noticeable in the full-circular type of crest. Danish Pieds and similar birds having a recessive gene are best avoided for crest production, as it is next-to-impossible to improve their size or quality for exhibition purposes. It is also extremely complicated as the breeder would be trying to establish two diverse characters at the same time and

what might be good for one will often be bad for the other. If the breeder keeps to the crested normal type of bird with its dominant and sex-linked counterparts as outlined above, the results should be attractive birds of quality that do justice not only to the Crests but to the breeder's' hard work.

Chapter 6

EXHIBITING CRESTED BUDGERIGARS

The Crested Budgerigar having been accepted as a class in the National Championship Show, it follows that many clubs throughout the various zones of Australia now include them as a class in their respective show schedules.

The Crested Budgerigar Club of Australia is committed to supporting the breeding and exhibition of the Crested variety. In the years ahead it will be the responsibility of all members of the Club to bring the Crested Budgerigar up to the same standard as all of the other varieties of exhibition budgerigars currently shown.

The "Description of Perfection" of the exhibition budgerigar and the “Variety Standards” for the various types of crested, together with a "Scale of Points" is contained in the Australian National Budgerigar Council's book "The Standard" 2014. [16] For the convenience of members, copies of the information relevant to Cresteds are included in this chapter courtesy of the ANBC.

To those budgerigar breeders who are starting with the Crested variety it will soon become apparent why the catchphrase "The Ultimate Challenge" has been adopted by the Club. The breeder of this variety not only has to produce a budgerigar which conforms in all respects to the exhibition standards but has also to conform to the standards for the type of crest. They will also soon become aware that not all the chicks in the nest will show a visual crest and even more rare the number of "Full-Circular" are even fewer, this is the challenge all crested breeders face.

With the importation of British bred birds during the early 1990's we have seen feather improvement in our Australian birds. Generally the coarser longer feather of the British bird has improved the appearance of our birds. Many breeders are using the British bred stock with the Australian crests and have been successful in breeding larger Crested budgerigars. Time will tell if Crested breeders are able to maintain or indeed improve the Exhibition Crested.

AUSTRALIAN NATIONAL BUDGERIGAR COUNCIL
DESCRIPTION OF PERFECTION

Condition:
The bird should be clean and sleek, complete in feather, showing vitality and good health with no sign of injury or disease.

Type:
The bird is to taper gracefully and be well proportioned according to the pictorial of the time, standing well off the perch, at an angle of approximately 30 degrees from vertical, with beak tucked deep into mask, backline sweeping gently, in a slight concave from the back skull to the tip of the tail. Body line to curve out from the beak through the mask to the chest, and then taper back to the lower tail coverts of the tail.

Length:
The ideal length is 240mm measured from the crown of the head to the tip of the tail.

Wings:
Firmly braced close to the body, neat and not showing too much back. The tips of the primary flights to meet at or just above the cushion of the tail. Seven or eight visual primary flights on each wing are acceptable.

Tail:
Straight and tight with two primary feathers in proportion to the size of the bird. The ideal tail length is 35% of the length of the bird.

Head:
The head is to be large, rounded and wide when viewed from any angle; curvature of the head is to commence at the cere to lift outward and upward, continuing over the top in one graceful sweep and merge into the backline and shoulders.

Eyes:
Bright, set deep in the head, well down from the crown and slightly nearer to the beak, than to the back of the head.

Cere:
Neat and shapely, of a solid and even colour.

Beak:
To be smooth and clean.

Mask and Spots:
The mask is to be clear, wide and deep, (not cleft) extending beyond two large cheek patches. Where required by variety standards the mask is to be ornamented by six evenly spaced, large, round throat spots, the outer two being partially covered by the base of the cheek patches.

Legs and Feet:
To be clean, with two front and two rear toes and claws gripping the perch.

Markings:
Where required by the variety standards are to be well defined.

Colour: Colour is in all cases to be pure and uniform in tone except where otherwise allowed in variety standards.

SCALE OF POINTS

A guide to the relative importance of exhibition features

TYPE

60 points (Refer Note 2 below for Crests)
General conformation, including size, balance, deportment, condition, head size and shape and depth and width of mask.
(Refer to "Description of Perfection" and "Pictorials, including Crested Pictorials").

COLOUR AND MARKINGS

40 points (Refer Note 2 below for Crests)
COLOUR: Quality of colour in body, ground areas and markings
MARKINGS: Pattern and clear definition or absence as required by variety standards

Allocation of available points for colour and markings to be determined by three variety groupings as listed below

1. Colour and absence of markings are of paramount importance	2. Emphasis on Markings and/or Varietal Features (refer note 2 below)	3. Equal weight given to Colour & Markings or absence of markings
Red Eyed Self Spangle Double Factor Dark Eyed Clear	Opaline Greywing Cinnamonwing Clearbody Lacewing Fallow Spangle Recessive Pied Saddleback **Crested**	Normal Green Series Normal Blue Series Normal Yellow Faced Blue Series Black Eyed Self Clearwing Dominant Pied Group Darkwing Dilute

NOTE 1: Combination varieties - allowance should be made accordingly.

NOTE 2: Given the Crested is the only Budgerigar with a distinct varietal feature affecting the outline, the points for Type, Colour and Markings are to be allocated as follows –

- 30 Points – Prominence, neatness and central positioning of the Crest
- 50 Points – Type
- 20 Points - Colour and Markings

CRESTED:

Three forms are recognised – FULL CIRCULAR, HALF CIRCULAR and TUFTED and their ideal forms of this unique varietal feature are as illustrated in this Standard.

In every case, the crest should be large in size and complete in feathering so that it is the prominent varietal feature and is to be allocated 30 points. Except for this additional feature affecting the outline, the Standard for Crested is as for the Colour and Variety involved with the remaining 70 points allocated for Type, Colour and Markings.

FULL CIRCULAR: Should be a full flat round crest with feathers radiating from the centre of the head. The Crest should fall in a neat circle around the head and be complete in feather.

HALF CIRCULAR: Should be a forward facing half circle of feathers radiating from the centre of the head, falling or raised ideally 8mm in a fringe from above the cere.

TUFTED: Should be an upright crest of feathers ideally 8mm high rising from just above the centre of the cere.

Note: While only these three forms of Crest are recognised the FULL CIRCULAR is seen as the ideal expression of the variety and preferred over HALF CIRCULAR which in turn is preferred over TUFTED. Size, symmetry and central placement of the crest is seen as a paramount feature.

Penalties:- where a bird has an incomplete crest, damaged or untidy crest, multiple crests, crest off centre or has a crest or feather disturbance outside of the areas allowed for in The Standard. Any detectable trimming refer Disqualifications section.

Chapter 7

CLUB ACTIVITIES

The Objects of The Club are ….:-

1. To encourage, promote the breeding and exhibition of the Crested variety.

2. To collect and publish information relative to the Crested Budgerigar or other matters of interest to members of the club.

3. To assist with the adoption of a Standard of Perfection for the Crested Budgerigar and to revise it when deemed appropriate.

4. To Conduct exhibitions of the Crested Budgerigar.

5. To take such actions and to do such things as may be considered expedient to the pursuit and furtherance of the objects of the club

6. To affiliate or liaise with any Society or club with similar interests.

The "Maurice Roberts" Perpetual Trophy Awards

At the Annual General Meeting of the Club held at the "Mecure Resort" on the Gold Coast, the guest judge from the United Kingdom Mr Maurice Roberts being in attendance expressed a wish to donate a perpetual trophy for the best crested budgerigar at the ANBC show. The offer was kindly accepted and the trophy a beautiful crystal decanter, engraved with the image of a crested budgerigar was finally received at the Annual General Meeting held at Fremantle, West Australia in May 2001.

2000	Rob Hugo
2001	Rob Hugo
2002	Rob Hugo
2003	Kelwyn Kakoschke
2004	Painter and Bird
2005	Kelwyn Kakoschke
2006	Ken Seagrott
2007	J & B Goodworth
2008	Sheppard and Flanagan
2009	Garces Family
2010	Sheppard and Flanagan
2011	Sheppard and Flanagan
2012	Sheppard and Flanagan
2013	Sheppard and Flanagan
2014	D and R Lange
2015	K and S Alsop

NATIONAL WINNERS

2000 ROB HUGO

2003 KELWYN KAKOSCHKE

2001 ROB HUGO

2004 JEAN PAINTER

2002 ROB HUGO

2005 KELWYN KAKOSCHKE

2006 Ken Seagrott

2007 J & B GOODWORTH

2008 Sheppard & Flanagan

2009 J & G GARCES

2010 Sheppard & Flanagan

2011 Sheppard & Flanagan

2012 Sheppard & Flanagan

2013 Sheppard & Flanagan

2014 D & R Lange

2015 K & S Alsop

The above photos provided courtesy of the ANBC and/or Nola Bradford.

The Golden Crest Award

In 2009 the concept of an annual pointscore competition called the "Golden Crest Award" came to light, with the competition eventually commencing after the 2010 AGM. The aim of the competition was to promote the exhibiting of the Crested variety in other clubs throughout Australia.

Points were awarded to each exhibitor winning major awards with crested budgerigars at any participating show. The annual pointscore winner won a prize and free one year membership to the CBCA.

2011	1st -Sheppard & Flanagan 2nd -J & S Bucior 3rd - S Conroy / C&M Wyllie
2012	1st - Sheppard & Flanagan 2nd - G Job / S Wackwitz / C Gearing
2013	1st - Sheppard & Flanagan 2nd - K Yorke / K&T Morgan / D&G Pymont / D&M Campbell
2014	1st - Sheppard & Flanagan 2nd - S&R Foster / G Job / D&G Pymont / K Yorke
2015	1st - D&R Lange 2nd - G Job / K Yorke

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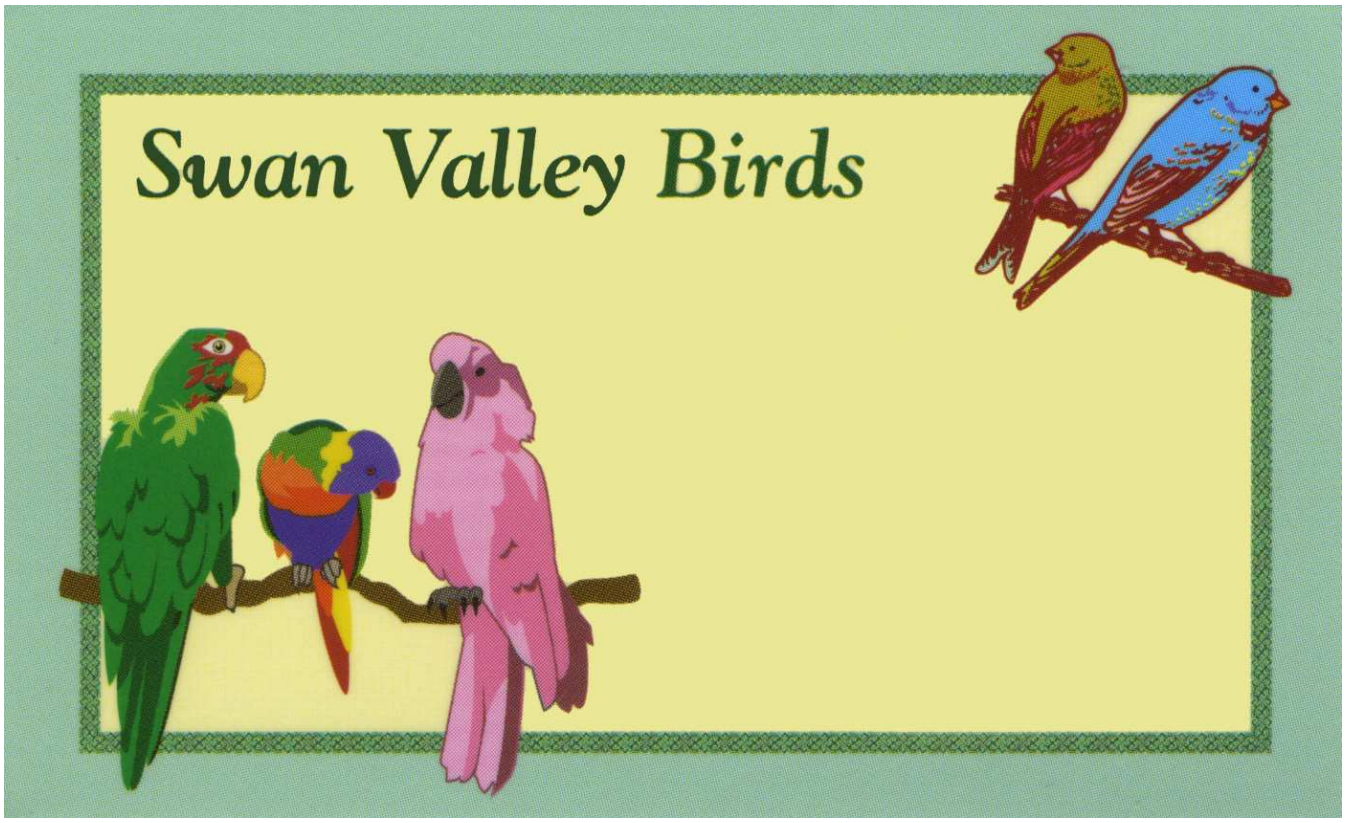

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