A review of moulting and feather wear; applications for clinical practice

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Introduction

Feathers are the modified epidermal structures that characterise birds. The purpose of this presentation is to review the basics of quality assessment, moult and wear of feathers and to outline some techniques that clinicians can use to assess moulting stages. Being able to interpret these feather patterns can give insights into prior stress (such as nutritional deficiencies or episodes of anorexia) and the course and chronicity of disease.

Current techniques used to evaluate feather quality

1. *Fault bars*

These are sometimes known as stress lines. Simply by holding a feather to the light it is possible to identify transverse lines of weakness in the feather vane. These are correlated to periods of food deficiency while the feather is growing. If the bird is juvenile then the fault bars will be aligned across feathers as the tail feathers develop synchronously. Feathers will often break at these points.

2. *Rachis flexibility*

Hold the rachis (feather shaft) at its base and pull its tip down to meet it. In a healthy feather it should flex smoothly and, when released, spring back to its original position. This gives a subjective assessment of rachis quality. In nutritionally deficient birds the rachis is often brittle and will break or bend rather than flex. A finer assessment of flexibility can be made by the feather's return to the upright position, as poorer quality feathers will not snap back with the same elasticity as healthy feathers.

3. *Rachis diameter*

Diseases that cause inflammation in the feather follicle will result in a severe pinching of the growing feather shaft. This is particularly noticeable in Psittacine Circovirus Disease, but can be a feature of any folliculitis.

4. *Sheath retention and barbule interlocking*

These are not necessarily indicators of poor feather quality, but can signify reduced preening by the bird. The keratin sheath of a growing feather is usually removed daily by the bird in the course of normal feather maintenance. If there is generalised retention of sheaths it may indicate general debility. Localised areas of feather retention may suggest the bird is unable to reach the area to preen. E.g. Tail feathers may not have the sheaths removed by calcium deficient birds with spinal lordosis.

5. *Feather colour and iridescence*

Knowledge of the normal feathering and possible genetic mutations is essential to interpret apparent changes in colour and iridescence. Colour is usually due to pigmentation and can therefore be altered by dietary deficiencies, excesses and supplements (E.g. Canthaxin or spirulina is used to produce red colouring in canaries). However, iridescence is a structural property and its lack can be used as an indicator of poor feather quality. Our knowledge of the basic biology of feather colour is inadequate. The full qualities of many feathers may be beyond our perception as some birds reveal spectacular colourations under UV light.

Moulting

Moulting can be defined as the energetically costly replacement of feathers. Moulting strategies have been evolved to maximise the survival of the individual during the loss of feathers. These strategies range from the gradual loss of feathers seen in Australian honeyeaters where moult can extend over three to four months, to the rapid and complete moult of some Australian waterfowl. Complete moults are uncommon as they leave a bird flightless and vulnerable. The birds that adopt this strategy usually have a "sanctuary" where it is relatively safe to be flightless. Rapid moulting usually causes a drastic reduction in bodyweight as feathers are replaced. A gradual moult allows a bird to spread the high energetic cost of moulting over a longer period of time.

In most temperate birds the moulting cycle is of twelve months duration. In tropical and oceanic species the moult cycles are often less than one year and moulting cycles which extend for greater than twelve months occur in some species.

Types of Moulting

1. *Postnuptial moult.*

This is the most common type of moult where there is a single complete annual moult involving the body, tail and wing feathers. It occurs following breeding. Feather loss may be bilaterally synchronous and progressive (eg. Parrots and most passerines) or involve a simultaneous wing feather moulting (eg. some waterfowl where a suitable refuge occurs)

2. *Prenuptial moult.*

This usually occurs in sexually dimorphic species where plumage plays a role in attracting a partner. Time of moult varies with species and with sex, males often moulting into breeding plumage earlier than females.

3. *Interrupted moult.*

This occurs where time or energy constraints halt moulting part way through a cycle. It is usually recommenced at the point where moulting was ceased. For some species this has become a normal cycle. eg. Red necked night jars (*Caprimulgus ruficollis)* have a moult which is a cyclic process of periodically suspended moult stages. This is believed to be a strategy aimed at coping with the short time available between breeding and autumn migration and the steep decline in food resources.

Endocrine Correlates

The endocrine mechanisms of moult are not completely understood and vary widely with species. Some generalisations can be made and the moult can be induced by a number of different mechanisms. This may be useful in cases of severe feather dystrophy rather than manually plucking feathers. Inducing moult can also be useful if trying to return a bird to flight performance quickly (eg. Raptors).

1. *Thyroid hormones*

   In most studies moulting correlates with peaks or at least elevations of thyroxine. T4 and T3 are suspected to differ in their roles but the exact nature of these is undetermined. Supplemental T4 can induce moult in a range of species. However, it is suspected that thyroxine has only a permissive or organisational role in moulting. Supplemental T3 in poultry can cause a delayed return to lay and inhibit moult.

   Propylthiouracil (PTU) induces transient hypothyroidism when given orally. In poultry this causes the cessation of lay and the inhibition of moult (but doesn't completely stop it). When PTU is withdrawn lay will recommence without normal moult cycle.

   Radiothyroidectomy in sparrows has differing effects depending on the photoperiod when treatment given. If it is done before photostimulation then testicular growth and moult were inhibited but not completely prevented. This illustrates the importance of not relying solely on hormonal supplementation to induce moult. Photoperiod and environmental modifications are also necessary.

2. *Luteinising hormone and testosterone*

   Supplemental androgens can delay or inhibit moulting in a range of species. Testicular regression is needed in sparrows prior to postnuptial moult and the nuptial plumage of some male ducks is exhibited by both species following gonadectomy. It is believed that this breeding plumage is developed in the relative absence of gonadotrophins.

3. *Photorefractoriness*

   In some wild passerine birds studied (sparrows, swallows and starlings) manipulation of daylight hours to long daylength can lead to testicular regression and postnuptial moult.

   Experiments with radiothyroidectomy suggest that endogenous thyroid hormones and long days may interact during a critical period to program the physiological sequence of events of photorefractoriness and moulting.

4. *Cortisol?*

   In arctic breeding birds such as snow buntings and Lapland longspurs, moult is correlated with dramatically reduced baseline and maximal cortisol plasma levels. This appears to be a reduction in adrenal capacity, as ACTH stimulation will not raise values. The effect is lost in captive birds. This raises the possibility of differences in moulting controls between captive and wild populations of birds. The significance of cortisol in moulting is uncertain.

Summary

Moulting would appear to be controlled by a complex interaction between elevated T4 and reduced gonadotrophins. Photoperiod and cortisol may be important in some species. There is tremendous species variation. Manipulation of the moult hinges around causing either elevated T4 levels or reduced gonadotropins, possibly by using gonadotropin releasing hormone analogues. Reducing daylength and nutrition to maintenance or sub-maintenance levels may also be used.

Other factors controlling moult

1. *Body condition*

Moult is an energetically demanding process and many species will not moult if in poor body condition. eg. in Shy Albatross the arrival mass of the males to breeding areas is positively correlated with the number of primaries moulted.

2. *Age*

A juvenile bird generally moults later in a season than an adult would. Many juveniles will have a secondary moult to replace juvenile plumage in between the times of the adults normal moulting cycle.

3. *Previous breeding activity*

In some species (eg. albatross) birds failing in a breeding attempt renew fewer feathers than those rearing a chick do. Birds will often delay moult till after chick fledging.

4. *Ecology*

Migration can impose time restrictions on moulting eg. Nightjars, waterfowl. Foraging, predator avoidance and the defence of territory are all needs, which have influence on a species moulting strategy.

5. Energetics/ nutrition

Abundant food resources can alter moulting patterns. eg. Fulmars in Arctic regions moult while they are incubating. This is thought to be a consequence of high food availability allowing reallocation of energy into moult during incubation.

5. *Other stresses*

The outer primary wing feathers of Albatross under stress are least likely to be shed.

Methods used in the poultry industry to induce moulting

1. *Weight loss*

Generally the weight loss needs to be in the order of 25-30% of initial body weight to initiate moult and both food and light restriction are used to accomplish this.

2. Mineral imbalance

High zinc, low calcium diets are used to induce moult. This may have serious side effects when used in longer living companion animals and is not recommended.

3. Hormonal induced

A gonadotropin releasing hormone (GnRH) agonist is used to induce moult and has the advantage of not causing a drop in body weight. These drugs have recently been used to terminate reproductive behaviour in companion birds. Veterinarians using this method should carefully document whether moulting occurs, as this drug is associated with a lower frequency of side effects than thyroxine when used to induce moult.

Recognising and recording moult

Ornithologists use two different methods to record moulting pattern. The simplest form is a shorthand description of the moulting stages of the 10 primary remiges.

Figures 1 and 2 show the terminology used. The first primary is the inner feather, i.e. the closest feather to the secondary feathers.

An example of a moult description of a swift parrot that is currently moulting its third, fourth and seventh primary, and has already moulted its second and fifth primary is O5225O53OO.

Once practised this technique provides a quick and easy way to record moulting stage for future reference. Old feathers are distinguished from new feathers by the degree of feather wear along their edges. Figure 3 shows some examples of feather wear. These can be recorded as “N” for new, “S” for slightly worn, “O” for worn and “V” for very worn. So the above might be noted asON22NSN3OO.

It should be noted that many birds have evolved coloured tips to their feathers, which wear faster than the rest of the feather. This can allow a bird to change colour dramatically without going through a moult.

The degree of feather wear gives an indication of how long the bird has retained feathers and is useful in identifying departures from the normal moulting cycles. A bird with a complete wing of very worn feathers has not been able to cope with the energetic demands of moulting.

The second method used by ornithologists is to use the same codes but applied to whole feather tracts. Figures 4 and 5 show the forms used to record moult in this way.

This is a much more involved method of recording moult but would allow description of a progressive feather disease.

NB. The codes next to the various feather tracts, e.g. Forehead (MH), are simply the computer codes the Australian Bird and Bat Banding Scheme (ABBBS) uses to record the data.

Fluctuating asymmetry in feathers

This is the asymmetrical growth of contralateral feathers and is being increased used by biologists as a measure of an individual’s fitness.

Increased asymmetry occurs with:

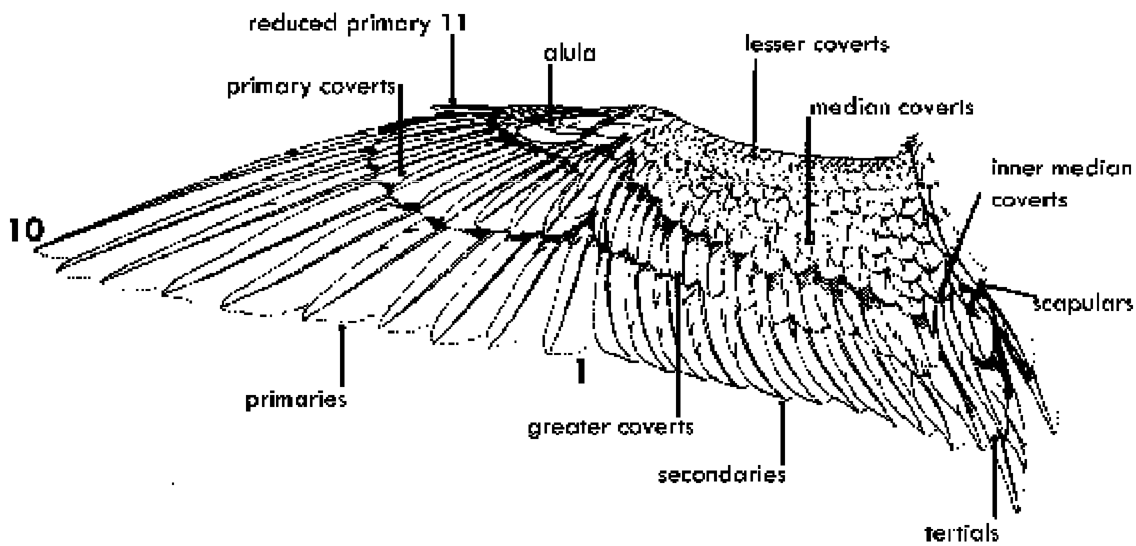
1. *Increased nutritional stress*
2. *Increased energetic demands*
3. *Decreased social ranking*

Theoretically this could be applied to any bird examination to give an indication of the individuals "fitness". However it is at this stage only a theoretical technique and has not been applied to clinical practice.

Conclusion

The appearance of the feathers is a record of events that have occurred during the life of that feather. Like most of us, the feather is most impressionable when it is young and growing, but age and wear also cause distinctive changes to its once fresh exterior.
Interpreting these changes can provide us with a retrospective window on the previous health of the patient and allow us to form some suspicions as to the character and chronicity of disease processes. Understanding the mechanisms involved in moulting can allow us to induce moult when severe feather disease exists or when a rapid return to good feather condition is needed.

Figure 1.



Nomenclature of wing feather tracts used in the text

Figure 2

Record stage for each feather as shown below:

0	=	Old feather
1	=	Missing or new feather in pin
2	=	New feather less then **a** grown
3	=	New feather **a** to **b** grown
4	=	New feather **b** to fully grown with trace of waxy sheath
5	=	New feather fully developed

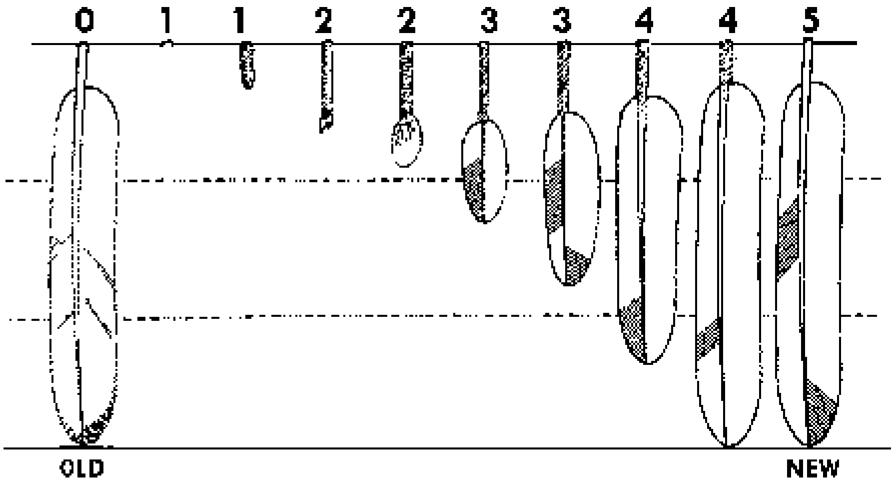


Figure 3

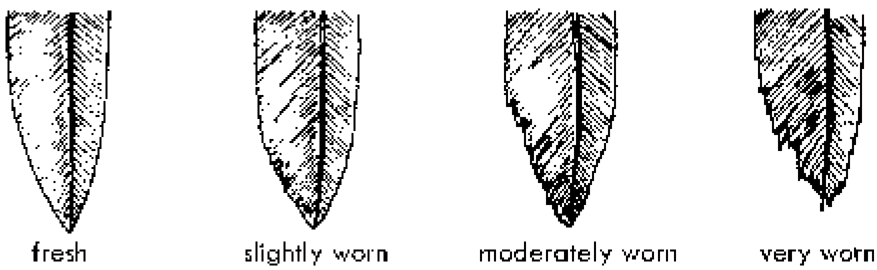


Figure 4.

AUSTRALIAN BIRD BANDING SCHEME

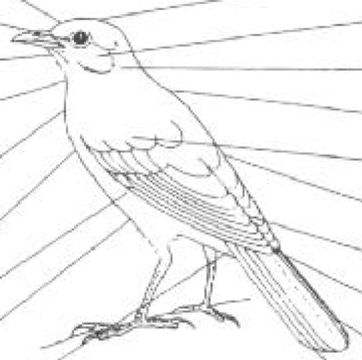
Moult Recording Sheet - Type I

Species: ______ No.: ____ Age: ____ Sex: ____ Band No.: ____ - ______

Location : ______ State: ____ Locode: ____ Method: ____ Status: ____

Date: ______ Bander: ______ Auth No.: ____ Processor: ______

BODY :



Forehead (MH) ____ ☐

Lores (MH) ____ ☐

Chin (MI) ____ ☐

Throat (MT) ____ ☐

Upper Breast (MB-U) ____ ☐

Lower Breast (MB-L) ____ ☐

Flanks (MF) ____ ☐

Belly (ML) ____ ☐

Undertail Coverts (MD) ____ ☐

* Covered by wing feathers in diagram

Crown (MC) ____ ☐

Ear Coverts (ME) ____ ☐

Nape (MN) ____ ☐

Mantle (MM) ____ ☐

Scapulars (MS) ____ ☐

Back (MM) ____ ☐

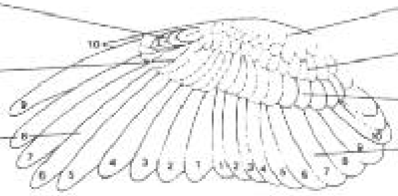
Rump (MR)* ____ ☐

Uppertail Coverts (MU)* ____ ☐

Tail - Right (M5-R) ____ ☐

Tail - Left (M5-L) ____ ☐

UPPERWING :



Alula (M6) ____ ☐

Primary Coverts (M3) ____ ☐

Primaries

Right Wing (M1-R) ______

Left Wing (M1-L) ______

Lesser Coverts (M8) ____ ☐

Median Coverts (M7) ____ ☐

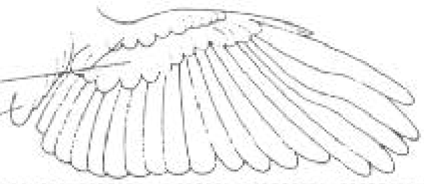
Secondary Coverts (M4) ____ ☐

Secondaries (& Tertials)

Right Wing (M2-R) ______

Left Wing (M2-L) ______

UNDERWING :



Underwing Coverts (M9) ____ ☐

Axillaries (M) ____ ☐

OTHER POINTS : ______

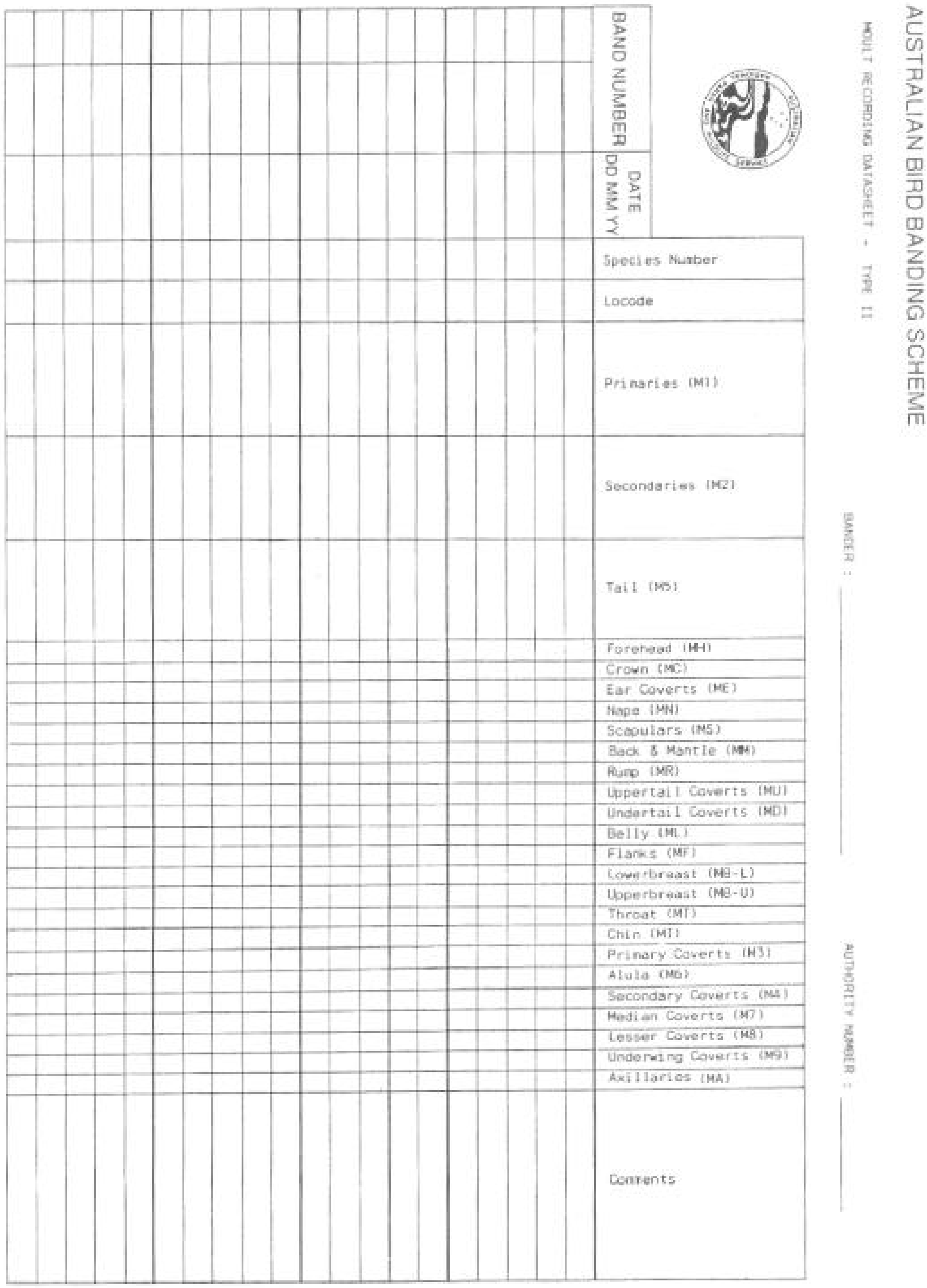
RECORDING CODES :

Wing and Tail : 0 = old feather, 1 = missing or new feather in pin, 2 = new feather less 1/3 grown, 3 = new feather 1/3 to 2/3 grown, 4 = new feather 2/3 to fully grown with trace of waxy sheath, 5 = new feather fully developed

Body Moult (including wing coverts) : 0 = no moult activity S = slight moult activity A = active moult C = completed moult

6.31

Figure 5



AUSTRALIAN BIRD BANDING SCHEME

MOULT RECORDING DATASHEET - TYPE II

BANDER :

AUTHORITY NUMBER :

BAND NUMBER
DATE DD MM YY
Species Number
Locode
Primaries (M1)
Secondaries (M2)
Tail (M5)
Forehead (MH)
Crown (MC)
Ear Coverts (ME)
Nape (MN)
Scapulars (MS)
Back & Mantle (MM)
Rump (MR)
Uppertail Coverts (MU)
Undertail Coverts (MD)
Belly (ML)
Flanks (MF)
Lowerbreast (MB-L)
Upperbreast (MB-U)
Throat (MT)
Chin (MI)
Primary Coverts (M3)
Alula (M6)
Secondary Coverts (M4)
Median Coverts (M7)
Lesser Coverts (M8)
Underwing Coverts (M9)
Axillaries (MA)
Comments

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