

# Protocol for Scale Hive Measurements of the Honey Bee Nectar Flow

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## **Objective/Introduction**

A program for measurements of hive weight provides useful insight into the condition and activities of the honey bee colony, the timing of the honey bee nectar flow, (HBNF) and success of the interaction of the bees with their environment, and will provide a means for collecting and preserving the weight records. A variety of papers describe a range of weighing techniques that yield useful information for colony management purposes, most recently reviewed by Szabo and Mueller (1996, *American Bee Journal* 136:417-419). The purpose here is to provide a simple protocol, or recipe, for making scale hive measurements that provide insight into how the timing of the HBNF varies across the county and state, and over the years.

The objective of these measurements is to provide multi-year to decadal records of HBNF timing to document its variability, and to assess and predict the effects of climatic change and land cover/land use change. A scale hive record will give the beekeeper valuable information on the current status of the colony, when the nectar flows occur and their duration, when swarms issued, and status of stores for over-wintering. Collections of these records provide a historical educational resource for the beekeeper, both individually and for local clubs and associations, and scientific investigators. Maintenance of such records (including publication) provides a record useful for future investigations and comparisons.

The timing of the nectar flow depends strongly upon the local plant flora, and how those species respond to local weather and climate. Local/regional surveys of the nectar flow provide useful information on the abundance and distribution of the nectarous flora, and if taken over years, can detect land cover/land use changes as well as climate related changes.

This protocol gives recommendations on scales and their use, colony selection and management, and suggestions of what to do when the unexpected occurs. This protocol was written to provide guidance for volunteer beekeeper citizen/scientists, since only through their participation can large scale surveys of the nectar flows be conducted. It assumes some background in beekeeping, but it is hoped that it will also be useful for the non-beekeeper ecological/climate scientist who might consider rental of a colony to augment the current suite of environmental variables taken at test sites. The collection of such data would provide a greatly improved (if not essential) basis needed to relate climate change and ecological responses to potential impacts on the nectar flows and plant-pollinator interactions. Graphing, plotting and analysis of records will be treated separately.

Measurements can begin at any time in the year. Plan to begin measurements by mid-March to capture the primary, or main nectar flow in the Tulip Poplar regions of Maryland (G. Abrams, 1957, *Gleanings in Bee Culture* 85:34-35), and continue them through the month of June and past July 4 if gains are still being recorded. The beginning should be before the first 'build-up' flows from mustards, cresses, and dandelion commence. The dates should suit your locality. The record may be monotonous for a while, with slow continual loss, until the spring flows begin. Very few records exist to document minor flows occurring during the summer dearth and the fall aster/goldenrod flows in central Maryland, as these have been considered pretty boring and less important for bee management. Good records during those times will therefore be important for

understanding the complete annual cycle, and may provide very important information with respect to whether the native flows could support resident populations of the Africanized Honey Bee.

Use of brand names does not represent an endorsement by NASA.

### **The Scale**

The classic scale used for monitoring hive weight is the traditional manual platform beam scale (also known as a “feed scale) with a deck about 17 x 24 inches, total capacity of 500 to 1000 lbs, and a minimum weight sensitivity of 0.25 lbs. The precision (how well a measurement can be repeated) and relative accuracy of these beam scales is determined primarily by sliding a weight (the counterpoise) along the beam. Old scales are usually surprisingly accurate and precise. This is the type of scale recommended above all others. Various manufacturers and designs are available, with Fairbanks being the most common manufacturer.. I have also seen Detecto, Chatillon, Howe, and Toledo models, some with 0.5 lb sensitivity. Cost new is about \$450. Used units are frequently available at farm auctions and stores, and over the internet, sometimes for as little as \$25, and most are quite adequate for this purpose. Occasionally, interested farmers, recognizing the value of honey bees, have donate unused scales for this activity.

The principle of the operation (lever arm beam balance) is robust, insensitive to temperature, and exposure to the elements, and relatively insensitive to rusting. The models with cast iron bases range in weight from 150 -190 lb. A medical platform scale can also work (they commonly have 400 lb capacity) provided the hive can fit on the platform (about 10” x 14”). I believe an 8-frame hive, set sideways, would fit OK fit since its width is 13.75 inches. Generally, used scales are graduated in terms of pounds (Avoirdupois); more recent scales can be in either pounds or metric (Kilograms) measure. Either one works fine. Values should be recorded and reported in the units used on the scale. For reports in the scientific literature, which requires metric units, the Avoirdupois units can be converted during the final analysis.

When evaluating a used scale, check its operation carefully. Tilt it over or lift up the platform (may require removal of rusted screws holding the platform cover in place), and make sure the bearing surfaces and “knife edges” are present and undamaged. Some rust on these parts is not a big problem, and they respond well to a wire brush. The lever arm should move freely when the scale is upright, and if both the counterpoise and the beam are brass the numbers should still be legible. The embossed numbers on beams can be made more legible by using a wire brush, then rubbing on some light oil. The mechanical advantage of the scales (also called the multiplier) is usually 100:1 – a 1-pound weight on the weight pan balances 100 pounds on the platform. There is usually an adjustment for zeroing the scale – this is not crucial for our purpose and if the adjustment on a used model is rusted tight the scale can still be used. Often there is a ‘locking’ screw on bottom of the counterpoise, which can go missing. Lack of it will cause the poise to be much too light, but these can be replaced with a substitute. Check to make sure a complete set of weights is available, although individual ones can be bought separately or made. A harder problem is a missing weight pan, but that can also be overcome by making a substitute (they weigh about pound) or buying a new one and making simple adjustments.

You should expect the colony and hive to vary between about 60 lbs to well over 300 lbs, depending on your location. You want the scale to be accurate to within few tenths of a percent (to within a half a pound or less). This should be checked out, especially for used scales, using various weights.

The scale should be located on a level, solid surface, and in a location convenient to making evening or morning readings. A small concrete pad, or carefully laid paving blocks on a bed of gravel is great. A sturdy wooden frame made of treated lumber can also suffice if it is well supported and level and does not warp when wet. Remember it will have to support a total weight of over 500 lbs, so don't skimp. A solid foundation will also prevent weeds from growing up into the works, which could cause problems and increase dampness and rusting. A recommended addition to older scales is a small bulls-eye bubble level, or surface level having two linear vials at 90 degrees, epoxied to the platform or base near the pedestal. A carpenter's or mason's level can be also be used. Cedar shingle shims under the wheels provide the final adjustment.

A three-sided shanty or a roof for protection from the weather and wind makes a nice addition, especially if you are going to include electronics, but this is not essential. An alternative is to place the scale and hive in a larger open-sided shed if the bee traffic can be tolerated, but stay away from garages with exhaust and pollutants. Some additional weight will be noticed during rainy periods for exposed scales, but will rarely exceed a quarter pound (~1/2 cup of water collecting on the outer cover) and can usually be ignored. Snow/ice needs to be swept off, but the need for measurements during such periods is minimal. A good alternative to the shanty is to construct a small protective cover out of aluminum flashing material to shield the beam mechanism and protect it from the weather.

Avoid spring scales, and hive weight indicators with a single lever indicator (pointer) sometimes sold by bee supply houses. The latter are very insensitive to weight changes. Vertical spring scales require you to pick up or hoist the hive for weighing, and may require two or more people. They are not very practical (except perhaps to weigh each hive once before winter to very roughly estimate stores) and are also imprecise. I have weighed hives with a spring scale by picking up only the front an inch or so, and multiplying by 2. The accuracy and precision of this approach is over the limits we would like to achieve.

It is possible to adapt a bathroom spring scale, often available with 1 lb readability, for use under a hive. A version of this will be tested in Maryland in 2007 by Allen Hayes, in comparison to a balance scale, to see if it can give adequate performance.

Electronic scales are coming on the market, but there is currently no low cost model that runs on batteries, is weather proof, and has sufficient accuracy over the range of temperatures encountered. Re-zeroing is a problem, as well as confidence in the accuracy over time, since most electronic scales are designed to be turned on unloaded, automatically "zero" themselves with no load present, followed by determining the load weight a short time later. They will work only if you want to lift the entire hive on and off in a few seconds, every time you want to weigh it. In addition, accuracy depends on temperature. It's fairly easy to tell if the mechanical balance beam scale has a problem, not necessarily so with an electronic one. Hopefully some manufacturer will remedy this situation and market something affordable.

## **The Hive**

The platform scale described above is compatible with standard Langstroth-type hives, either in medium or deep hive bodies. The front of the hive can be placed at right angles to the scale, with the entrance to the side of the scale and the scale's beam mechanism to the side of the hive if necessary on some shorter platforms. Some platforms can accommodate a hive placed with its back to the scale beam column. Be careful to allow adequate clearance between the hive and the beam housing to accommodate a telescoping cover after you have put supers on. Sideways mounting lets you insert and remove "sticky boards" from the rear, and to clean off the junk that falls through screened bottom boards, since the pedestal is not in way. Side mounting places the observer closer to the entrance, which is only an issue for some colonies and when you have to ask the neighbor kid to record the weight when you go on travel. I recommend the use two metal bars, pipes, or lengths of angle iron, set crosswise, to support the hive stand/bottom board on the platform for easier cleaning, better drainage, and ease in picking up the hive. Wooden supports will soak up water during rainy periods which may affect the weight.

**DO NOT LET THE COLONY RUN OUT OF EMPTY COMB.**

Make sure you have an abundance of supers with empty drawn comb. I generally start with four at the end of March, and have increased to seven on one occasion. Lack of empty comb for nectar storage can put a major dent in nectar collection, and encourages swarming.

## **The Colony**

Use care in selecting the colony to put on the hive. I recommend a medium strong, healthy colony, as you especially want it to prosper, stay put, and not swarm. A minimal pollination strength colony (6 frames of bees and brood) in two deeps or 3 mediums would be a good size colony. The colony should have received stimulative feeding, (light syrup, and pollen patties if needed) and it may continue to receive stimulative feeding until the flow commences. Resist the temptation to put your strongest colony on the scale in hopes of setting a new local record for daily gain, unless you are absolutely certain that it will not get into the swarmy mode as compared to the nectar collecting mode. If you are absolutely certain of this, please let the rest of us know how you figure that out!

Manage this colony for successful extracted honey production, in the manner to which you are accustomed. A young marked queen, healthy abundant bees, and good equipment is best. You want a colony that you can manage confidently. You will be spending a good bit of effort making those measurements, and you do not want to risk losing the good data continuity (not to mention the honey) because it swarmed. (although this need not mean the end of the record – see Special Cases).

You can perform all needed management manipulations like reversing brood chambers, feeding the colony syrup, grease patties, and pollen patties, etc. directly on the scale. You must just note the weight changes before and after such procedures. When you remove that empty syrup jar and protective hive body/box, or miller feeder, be sure to record that weight loss.

Plan on weighing the colony routinely either after all bees have returned (at dusk - ½ hr after sunset), or before they have begun to leave ( ½ hr before sunrise on warm

days). Hive weights can change rapidly during the daytime near the peak of the nectar flow (more than a pound per hour in central Maryland) . You might also have 3 pounds of foragers returning. You will undoubtedly miss some days (see below), but try especially hard to take a reading at the appropriate time on one given day of the week. Pick a day that is most convenient for you, and call this the key day. This will preserve a good weekly gain record, although it will miss the daily variability.

### Swarm Control

Inspect the colony weekly, briefly, for signs of swarm cells, and congestion. By briefly I mean one or two minutes or less, especially on good days, and with minimal smoke. Look for larvae, active queen cells with royal jelly, capped swarm cells, and empty comb. If it looks fine (no swarm cells, larvae, room in the supers), close up gently and get out. Plan manipulations and swarm prevention procedures ahead of time. Your scale record will convince you that drastic or lengthy manipulations can have major impact on colony behavior for that entire day.

Swarm prevention procedures that have significant impact on nectar/pollen collection behavior should be avoided if possible, even if the impacts might be temporary. This includes re-queening during the nectar flow, temporary queen removal/caging, and the like. Removal of frames of bees and brood (not the queen), and substitution with foundation or drawn comb have minimal impact on collection, but you will want to weigh the collection of new items before you put them in, and weigh the removed items, and note the difference. Remember, our object is to try to keep the nectar foraging activities of the colony steady throughout the spring.

Several previous articles have recommended a “minimal management” approach for scale colonies (e.g. Burgett, 1987 Gleanings in Bee Culture 115, 694-697.) which included natural queen rearing, but maintaining extra supers at all times. Several of those were written before mites, and the rationale was to include the natural over-wintering and spring build-up of the colony as one of the environmental variables to be monitored, along with the weather, climate, and foraging conditions. The interest was on colony yield, and the condition of the colony was treated as a component of natural variability; the timing of the nectar flows was of secondary interest. This is not quite what we are doing here. Here, the idea is to have the colony of bees at roughly even strength from one week to the next, so that it can faithfully collect any available nectar in an amount that the scale can detect, and thereby record the timing of the nectar flows. This calls for keeping the colony healthy, queen-right, and strong.

We encourage over-supering, or providing more than sufficient drawn comb for nectar storage, because we do not want the colony to run out of room, and because empty comb encourages nectar foraging. We do not recommend that the scale colony be used for comb honey production for this reason. Although comb honey management would not necessarily preclude a useful record, it might reflect a slightly different nectar flow from an adjacent colony maintained with excess drawn comb. Also, the reduction of brood nest volume, or crowding, is a common management technique to encourage rapid comb building in comb honey supers, which also would perturb the weight record. Comb honey colonies tend to produce less total honey because of the required management needed to fill those beautiful frames with the highly saleable product. So, use another colony to make your comb honey.

Bottom or top supering is always a matter of opinion at gatherings of beekeepers. I exchange several new frames of comb with frames that are being worked to provide empty space next to the excluder. I use an excluder. When the first supers go on, the bottom-most super goes under the queen excluder until the queen lays in a frame or two. When this occurs, usually in a week or so, I find her and move her down into the brood chamber, and put the excluder between the brood chamber and that first super with larvae. The bees readily go up through the excluder to tend the brood, and the brood in that super will have emerged and been replaced with honey long before harvest time.

### **The Log**

The log is the written record of weights, manipulations, and observations – the data. I now like to keep the log in a pocket yearly calendar book, together with a pencil (not pen) and pen-light in a zip lock bag. During the weighing season (March – whenever) I keep the bag on top of the beam support, under a removable aluminum sheet metal cover, where it is always convenient. I found out that a sheet of paper between the inner and telescoping cover was sometimes completely encased in propolis by the bees, and once it got chewed up and removed! Besides, you have to take off the outer cover to record the weight – not exactly a sting-free thing to do at late at night when you were late.

An alternative is to write the weights on the hive body or super. If you do this, be sure and include the day, month, and year as well, and use pencil to avoid fading and running of ink. This is the voice of experience. You should copy the log periodically to a table and/or computer spreadsheet, and you will likely want to graph the results. This helps minimize the loss if the logbook should ever go missing.

You need to include in the log book the daily weight at the end of the day, and the weight before and after you added or removed anything from the hive. All three numbers will be needed. Additionally, it makes sense to include a weather note, and to note what species are currently in bloom, and any colony notes (e.g. lots of bright orange pollen). Note conditions when you inspect the colony by opening it up, and the results (e.g. bees in supers, top super has nectar in 2 frames only). This is like a mini-journal. Log sheets are also available, can be kept in the scale housing, and work fine. I find that trusting scale readings to memory is no longer fail-safe (as attempted on a few occasions when I forgot to return the log book after transcribing the weekly numbers inside). I now write temporary numbers on the hive body (and hope I get the date correct) and transfer them to the calendar book ASAP.

### **Examples**

A simple and common example will be adding a super, usually during the middle of the day, and your custom is to record the weight at dusk. During the day, first record the weight of the hive without the super in the log. Place the super on top of the outer cover, and record the weight with the super in the log. The weight of the new super is the difference. The figures might be: “Add 1 super comb– Before 128 lb., After 142 lb.” Then, take it off, remove the outer and inner covers, (do a quick inspection, etc. – everything is OK), put the supers on, and close up. Note the change in the log for the date ‘Added one M drawn comb, +14 lb. Come back at dusk and record the total weight

for the day – maybe “144.5 lb. 8PM.” If the weight the previous evening was 125 lb, the natural gain of the hive for the day is  $144.5 - 14 - 125 = 5.5$  lb.

A common example of loss of weight due to management is removal of an empty feeder jar and its extra hive body. You will have added the total weight of the syrup, the jar, and the extra hive body before you first put the syrup on, probably a week earlier, and now the nectar flow is almost here and you need to remove them. During the day, for example, record the weight of the hive as it stands, remove the outer cover, empty jar, and extra deep, then put on the outer cover, and record the after weight in the log. Note “remove MT jar and deep – 8 lb”. Record the total weight at dusk as usual.

What about the weight of the syrup you added? That weight should not be included in the final removal step. You included the weight when you put the jar on, as a management weight change, and so you have already accounted for it. The weight of the syrup was not natural collection by the bees, and so it is properly subtracted, one time, when it is added, from the total weight of the hive. It then becomes part of the ‘tare’ weight. The sugar added will foster development of bees, just like the honey and pollen in the hive. Weigh grease patties before adding them, also pollen patties. Just cutting queen cells results in negligible weight loss (within reason) but if you have to cut cells, I suggest you might want to prepare for swarm control procedures and carry them out at the earliest opportunity. Weigh the burr comb if you remove a lot. Weigh the drone comb or frames you remove if you practice drone-trapping for varroa. Weigh the medications if you use formic acid or thymol wafers for mite control, when added and removed.

Weight changes for swarm control is more complicated, especially if you decide to make a split to reduce population and congestion. The net weight change due to your manipulation needs to be noted in the log. In swarm control, you will likely be both removing (frames, bees) and adding (new frames, or even a full box, preferably of drawn comb). Sometimes the hive is already open. In this case it is important to make the weight readings closely in time, before a thousand more bees have returned from foraging, etc. Weigh the new frames by noting total weight before and after resting them on the hive. Remove the frames (and bees) you want to remove, and note their total weight. Put the new frames in, and close the hive. This can be confusing and may result in a one or two day anomaly as the foragers from the split return to the hive, but your notes will alert you to be suspicious of the numbers. Use of the Demarree method is a much ‘cleaner’ method of swarm control, on the scale, as long as the total weight of equipment added is carefully noted in the log. There is no confusion of the weight change due to foragers “coming home” since everything remains on the scale, with the addition of a brood chamber and frames.

## **Special Cases**

### The Rock

It’s my habit to keep a small rock on top of the outer cover to prevent wind from lifting it, or pushing a feeder cover box off. It has happened. I take the weight without the rock. It weighs a couple of pounds. I would probably never be able to tell in retrospect if I inadvertently left the rock on, or left it off for a couple of days. I think I have gotten in the habit of removing the weather housing, then placing the rock on the

beam support, prior to taking a reading, and I often make a note 'rock off' in the log. I prefer to take it off rather than leave it on, because I might lose the rock, and it could absorb more water during rainy periods. Bricks and pieces of concrete block and wood do that. Just be consistent in how you treat such a weight.

### Missed Day(s)

A few are unavoidable, and have a relatively minor impact. A substitute weighing by dawn's early light comes close, but will not simply substitute for a missed evening weighing. There has been additional weight loss due to evaporation and respiration during the night. That loss will appear to decrease the actual gain on the day you missed, and will appear as an incremental increase the next day, sometimes of a pound or two. Several consecutive days are a bigger problem, but they will be correctly accounted in your weekly gain if you make a consistent weighing on a certain key day. Missing a week or more can give rise to very misleading records. The only analysis approach is to interpolate for the missing observations, but don't interpolate on the fly in the log book. Keep the weight blank, so you and others will know there was a miss. Try to make arrangements for a substitute person (spouse, kid, neighbor kid, etc.), if you have a planned absence of over a few days, especially if the "key" day is one you will miss. If the missed day was a good foraging day, and the next day that you can weigh the hive has been overcast and rainy with no foraging, note the weather. The gain can then be assigned to the first day rather than averaged across two days, with less error. (see Rainy Days, below)

### Swarm, Death of Queen, Disease

The most likely special case is that the queen dies, or the colony swarms, despite your best attempts, or the colony becomes mite ridden. For these conditions, the recommendation is to 1) note it in the log, then 2) switch the colony with a substitute colony from your apiary as soon as possible. Pick one which is in the nectar collecting mode if possible. Unless your apiary is extremely level everywhere, it may be easier to move the colony rather than the scale (but only if both colonies are healthy). During the day, with a friend if possible, record the weight, pick up the colony from the scale and move it adjacent to the replacement. If you and your friend are strong and have a hive mover this can be accomplished in a few minutes, otherwise you will have to break each down into more convenient units. Move the replacement onto the scale, record the weight. Then put the former scale colony onto the replacement stand. The change in weight is treated like a manipulation as above. Field bees will return to their former location, so the gain/loss will be suspect for a day or two (and for at least the week prior to swarming as well). The alternatives are to buy and install a new queen, or wait for the emergency or virgin queens to emerge, mate, and begin laying. That long delay results in a considerable period (10-30 day) hiatus in normal foraging, which will invalidate the record for following the nectar flow, likely for that spring. You need to decide what you want to do for the swarmed colony, but the quick substitution minimizes the impact to your scale record.

If you can't supply a substitute colony, then note it in the log, remove all cells, search for any virgins that may have already emerged, and get a new queen installed ASAP.

### Rainy days

A fully rainy day results in no gain and usually a loss during the nectar flow, as water from nectar is evaporated within the hive and bees consume some, and about a pound of bees may die daily. A weight is still very important, even if there is no net change. If the weight for a date is left blank, and the following day is a good foraging day, the analysis will have to assume that the gain made on the good day is spread over both the good and preceding rainy day(s) unless you make a note about yesterday's weather.

### Hive Beards

When the colony is very strong, and the weather is very warm and humid, bees cluster on the "front porch" for relief. This is called a hive beard (not to be confused with the bee beard stunt, and is a sign that maybe you need to add a super. It also might mean that the bees hang down off the scale platform and are resting on the scale base, resulting in a low weight by a pound or so. You might want to encourage them to go in with a little smoke, and put a new super on the next day, but otherwise you can forget about it.

### Bees under the bottom board, or under the scale.

I have had bees cluster under the screened bottom board, but above the scale platform. This was not a problem for weighing, but it tended to defeat the purpose of the screen since any mite that fell through had lots of bees to climb onto. I blocked the slit with a small piece of 8 mesh wire screen after blowing them out. On one occasion I had a swarm (not from the scale colony) elect to take up residence under the platform scale base, amidst all the scale works. I lost some days until I had time to clean it out and relocate the swarm. There is no good way to prevent this – the gaps between the platform and scale body, and under the cast iron body itself, are necessary for proper functioning.

### Preparations for Harvesting

Over-supering will likely result in lots of partially filled frames of ripening nectar/honey once the flow ends, making a nice clean harvest difficult. We all like those colonies with 2-5 supers of fully capped honey, little to no burr comb between them, and the top brood box well stocked as well, but such will not be the case with the scale hive if you have done your job right. You are still well ahead of the normal bloke, however, because you have a scale hive. You can make life a little easier when you notice that gains are steadily decreasing and the flow is beginning to shut down. Now you can combine mostly filled frames into one super, brushing all the bees off, and put that super on a colony that has capped most frames and is making honey-filled burr comb in between them, and hope that it finishes the added frames off. Just note the weight that you remove, and remember to leave lots of unfilled comb on the scale colony. You can even begin to crowd down your other colonies as well, now that you have a scale hive and can see that the flow is rapidly tapering off! See – all that effort has some practical benefit!

## Harvesting

The only comment here is that you should leave a partially-filled but mostly empty super on the colony after you remove the crop. This is to provide adequate room for any potential summer flows.

## Scale issues

Before first setting up your hive on the scale, check out and maintain your scale, and repeat this annually thereafter. Use a wire brush to knock off chunks of rust, mud-dauber nests, and dirt. Remove the platform and check for broken pivots and bearing surfaces. Spray the pivots and fulcrums and moving parts with a good dose of WD-40. Carefully level the scale using a spirit level, left to right and front to back, using shims under the wheels or legs. It is handy to glue a bull's-eye bubble level to the base if you have an old scale – some newer models come with one. They are available in most hardware stores for a few dollars.

Be satisfied that the scale reads zero unloaded, with just the counter-weight hanger in place and the poise (slider) at the zero position. If the beam pointer tops out with the poise at zero and nothing on the platform (a positive zero) try the tare adjustment near the beam pivot to turn the balance weight left or right. If this is rusted, you can add/remove small weight to the auxiliary weight pan (like a piece of copper wire, or penny(ies)). Usually the auxiliary pan has a compartment for adding weights. (I have found lead shot, fishing sinkers, nuts, washers, BB's, and a 1939 wheat penny in one). If the beam pointer bottoms out (meaning that the poise wants to be slid to below zero) or cannot be moved low enough to balance the beam, try moving the adjustment weight toward the beam pivot if possible. Check the pivots and fulcrums. Check that there is not extra weight on the auxiliary weight hanger. Or, add some weight to the scale platform. This could happen if the platform has rusted considerably, or if its a wooden platform with loss due to rot or decay or lost screws, and the weight of the platform has decreased. It should not be off by much. If the latter works, add the weight permanently by gluing or scewing a suitable piece of metal to the platform.

With the beam balanced on zero, add 50.00 pounds of test weight to the platform, and satisfy yourself that moving the poise to the 50 lb mark results in balancing the beam. A relative test can be made without resorting to accurate test weights – we are not striving for commercial accuracy here -barbell weights are fine. Or, just start filling a 5 gallon bucket with water or sand, and adjust its weight to balance the scale when the poise is set on 50.0 pounds. Then when you add the “50 lb/ ½ lb” auxiliary weight to the hanger, you should be able to slide the poise all the way to the left to the zero position, and the beam should balance. Likewise, if your scale reads exactly 100 lb (100 lb on the platform, with the poise at 50 lb and a “1/2 lb - 50 lb” counterweight in place) it should return to balance after you substitute a 1 -100 lb for the ½ - 50 lb counter-weight and move the poise to zero. If not, check to make sure the works are in the right position as above, that there is no foreign material between the base and platform, or within the vertical rod housing, and the fulcrums are not off their correct pivot points. If everything is in order with the mechanics, but the relative difference remains, then either the counter-weight or the sliding counterpoise is too light or too heavy. Check its weight on

an accurate laboratory scale or good commercial scale if possible. The underside of counterweights and the poise often have drill hole depressions where they were initially brought to exact weight by removing metal. You can add some lead shot to the holes, or if necessary remove some more. On two occasions I discovered that the bits of lead which had been inserted in the bottom of the poise to bring it up to the correct weight had dropped out over time. Resting two split shot sinkers on top of the poise made for correct balance. I put these into the bottom holes and pounded them in using a punch and hammer. On one scale the pan was missing completely and I made a new one out of a heavy wire and a metal disk, and made a 50 lb weight from lead.

The counter-weights should be maintained annually, and to within a precise tolerance. The definitive document is maintained by NIST as NIST Handbook 44 - 2007 Edition "Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices" and is available via the web for those who are interested:

<http://ts.nist.gov/WeightsAndMeasures/owmhome.cfm>

Table 1 of section 2.23 gives the following required maintenance tolerance for counterpoise weights for Class III scales that will be commonly used in for our purposes:

0.5 lb -  $\pm 160$  mg, or  $\pm 2$  grains,  
1.0 lb -  $\pm 190$  mg, or  $\pm 3$  grains,  
2.0 lb -  $\pm 380$  mg, or  $\pm 6$  grains

That tolerance is required for commercial use of the scale (which we are not doing), but it makes a good target. At that recommended level there will be no observable error to the reading (either 0.25 or 0.5 lb) when additional counter-weights are added, up to the capacity of the scale, and later users of your data can have full confidence in it. Usually someone in the local beekeeping group can provide access to a beam balance for checking the weights, and clubs can also arrange for an accurately weighed mass that can be taken from site to site to assure comparable readings. The recommended color for Avoirdupois weights is silver, like aluminum paint, gold for metric. Remember to adjust/record the weight after cleaning and painting the weights if you paint them.

A set of counterpoise weights (50, 100, 200) enables readings up to 400 lb. Having two 200 lb, one 100 lb, one 50 lb weights on the hanger, and the poise at the 50 lb mark, indicates a total of 600 lbs, far exceeding what I have ever used (which was somewhere near 370 lb). Scales of 1000 lb capacities often have readability of 0.5 lb, with the beam going to 100 lb and the smallest counter-weight is then 1 lb – 100 lb. Play with the poise near balance, and note how much the beam pointer moves with a  $\frac{1}{4}$  or  $\frac{1}{2}$  lb change in poise position. Its not much, so try to make sure the pointer is in the same position when you make your final reading.

After you have satisfied yourself that all the scale performs well with all the weight combinations you will need, you can make any temporary weight additions more permanent with a little epoxy. Make a record of when you weighed or calibrated the counterweights, and what you added.

Scale Stories

You have read this far – I hope you find this amusing. The old cast iron scales are extremely rugged. Once, I think in 1993 or 4, in early March, a deer ran headlong into my scale hive, and knocked in on its side. Deer tracks in the snow, with dog tracks along side, told the story, and the hive was in three separate piles. I saw it when I went to go to work, and immediately went to investigate. I found out very quickly that bees, even with snow on the ground, were still quite effective defenders and that they detest black wool socks, and I started hopping around. After getting properly dressed, I got most of the bees back in. The scale was none the worse for the wear, and the queen survived.

Second story. My hives are all in a row with a nice space between them for working from the side, and for mowing with my riding mower, with about 8 inches room to spare. My tractor died and I had to get a new one. The mower is 4” wider, but a bit more maneuverable, and I did not want to reposition 12 hives. On the third or so mowing I bumped the corner of the 2x8 frame the scale sits on, and the scale with hive proceeded to roll forward 6 inches and off the platform, all in breath-taking slow motion. When the front scale wheels dropped off the 2x8 frame onto the soft ground, the hive slid forward to the ground (about 6 inches), but did not separate and remained at about 30 degrees of tilt! The gallon jar of sugar syrup and the cover slid off, but the jar did not break even though it was 1/3 full. When I quickly pushed the scale up, and reset the hive, the scale did not work at all. The next day I found that the scale platform was misaligned and all the pivots and bearings were just displaced – knocked off position by the edge of the 2x8’s. It took about 10 seconds to reposition the knife edges on the levers onto the bearing surfaces, and everything was fine. It returned to the same weight (minus that of the jar and cover, that is).