Getting to the bone of the issue: could skeletal remains sustain obligate scavenging T-rex

In support of Scavenger

-Graeme’s paper (i.e without competition it can work)

-High bone content of coprolites (Chin et al 1998 & 2003)

-Body size distribution (Dave Hone et al ) and positive alloemetry of bone mass in carcasses (P et al ).

-Alloemetry of bite force

-Poor runner not capable of achieving speeds more then 11 m/s (Also got worse with age John Hutchinson)

- Olfactory ability (L. M. Witmer, R. C. Ridgely, Anat. Rec. 292, 1266 (2009). &

D. K. Zelenitsky, F. Therrien, Y. Kobayashi, Proc. Biol. Sci. 276, 667 (2009).)

-Good hight to see (Farlow 1994)

-Ontogeny argument (Russel 1970) can also argue for regional/seasonal differences

Against Scavanging

-Competition might be too much (This would be more to do with ontogeny more then anything Producer scrounger game?)

-Too hard too simply reach the carcasses? (Carbone et al)

-Digestion too fast/poor (Chin et al 2003)

- Not enough energy in bone & marrow (depends on proportion can argue from growth rates etc)

- Dont need to be fast other large dinos were very slow too

- Large bite force can equally be explained by predation (i.e hyenas are high but no higher then predators)

-Good vision (Negative allometry but in relative terms large enough Holtz in that book below)

-Good hearing (L. M. Witmer, R. C. Ridgely, Anat. Rec. 292, 1266 (2009). This can work fine with scavenging though)

-bite marks with visible healing – main one really but not defined as either a adult or juvinile

In between (Thomas R Holtz A critical reappraisal f the obligate scavenging hypothesis for t.rex and other tyrant dinos in Tyrannosaurus rex, the tyrant king)

Ways of figuring it out.

* Comparative analysis of large theropods and the maximum size of prey/ the degree of armour on prey. Include phylogeny to look at the derivation of comical non-slashing teeth and bite force. (Not sure how what the response variable would be)
* Look at the distribution of fossil skeletal elements and see if they match up with high fat bone fossil (this would provide evidence for bone scavenging but not who was doing it, tricky).
* Energetic model on bone munching and carcass dominating

Literature search

Hone D, Watabe 2010. New information on scavenging and selective feeding behaviour of tyrannosaurids. Acta Palaeontol. Pol. 55 (4): 627–634.

* Scrape marks from a Tarbosaurus which indicates scavenging. In contrast to t-rex it doesn’t seem to have punctured the bone as in triceratops pelvis puncture marks. These refs also indicate late stage scavenging due to marks in areaswith no muscle &poor quality. Overall it indicates more complex food choice then previously given, tyrannosaurs did necessary nom bones for the crack.
* Humerus of the hadrosaurine Saurolophus with feeding marks from giant tyrannosaurine *Tarbosaurus* (Is this an adult). The lack of damage to the rest of the otherwise complete and articulated hadrosaur strongly implies that this was a scavenging event, the first reported for a tyrannosaurid, and not feeding at a kill site. The best and most detailed example of Tyrannosaurus bite marks comes from the Triceratops pelvis described by Erickson and Olson (1996), which shows numerous deep bite marks and punctures but only a few limited scrape marks. This is remarkably similar to another specimen where a large tyrannosaurid had also fed on a large ceratopsid pelvis leaving puncture, but few scrape marks (Fowler and Sullivan 2006). Although Erickson and Olson (1996) did not specify whether they considered the Triceratops pelvis bite marks to reflect a predatory or scavenging event, the latter would seem more likely given that it appears to represent a very late−stage carcass consumption. This is also the case with the Fowler and Sullivan (2006) specimen where they inferred scavenging.

Nicholas J. Gidmark, Nicolai Konow, Eric LoPresti and Elizabeth L. Brainerd. 2013. Bite force is limited by the force**-**length relationship of skeletal muscle in black carp, Mylopharyngodon piceus. Biol. Lett. **9**, 20121181.

* Shows that species have a range of bite forces relating to gap size and which is hence prey size specific i.e hard stuff needs max bite at the size of the hard substrate. (we have a high bite force but cant crack open a walnut)

Christiansen, P and Wroe, S. 2007. Bite Forces and Evolutionary Adaptations to Feeding Ecology in Carnivores. Ecology, Vol. 88, No. 2 (Feb., 2007), pp. 347-358.

* Does what it says on the tin. Compares the bite force of carnivores to there ecology. Shows that hyper-carnivores and carnivores of medium sized prey have significantly higher bite forces then carnivores of small prey. Also shows that while for their size bone crushers have higher then expected bite forces their not insanely high or bigger then hyper carnivors.

Henry D. Prange, John F. Anderson and Hermann Rahn. 1979. Scaling of Skeletal Mass to Body Mass in Birds and Mammals. The American Naturalist, Vol. 113, No. 1, pp. 103-122.

* Scaling of bone mass with body mass in mammals and birds.

Stephen L. Brusatte, et al. 2010. Tyrannosaur Paleobiology: New Research on Ancient Exemplar Organisms. Science. 329, 1481.

* Overview of t-Rex research up until now. Good overview on ontogeny.

Chris Carbone, et al. 2002. A Common Rule for the Scaling of Carnivore Density. Science 295, 2273

* Carnivore scaling stuff.

Chin et all 2003. Remarkable Preservation of Undigested Muscle Tissue Within a Late Cretaceous Tyrannosaurid Coprolite from Alberta, Canada

* Preserved flesh indicates fast digestion (simlar to say a dog!)

Nicholas R. Longrich1, John R. Horner, Gregory M. Erickson, Philip J. Currie. 2010. Cannibalism in Tyrannosaurus rex.

* Finds several cases of what is most likely scavenging (due to place of scaring etc), most likely by juveniles tyrannosaurs species.

Paul Palmqvist et al 2011. The giant hyena Pachycrocuta brevirostris: Modelling the bone-cracking behavior of an extinct carnivore.

* Evidence and PCA analysis of jaw etc. evidence for scavenging of low density marrow rich bones (i.e there frequency distribution in the fossil record).

Bell, P. & Currie, J. 2010. A tyrannosaur jaw bitten by a confamilial: scavenging or fatal agonism?

* Tooth fragment of a Daspletosaurus or Gorgosaurus

May represent canabalism although tooth cannot be identified fully (**(Jacobsen 1998 apparently suggested cannabilim in t-rex**). It may also represent face biting behaviours.