

Growth hormone and thyroid hormone levels during smolting in different populations of atlantic salmon

Gilles Boeuf, Pierre-Yves Le Bail

▶ **To cite this version:**

Gilles Boeuf, Pierre-Yves Le Bail. Growth hormone and thyroid hormone levels during smolting in different populations of atlantic salmon. Progress in Comparative Endocrinology : Proceedings of the Eleventh International Symposium on Comparative Endocrinology held in Malaga, Spain May 14-20, 1989, 342, Wiley-Liss, 752 p., 1990, Progress in Clinical and Biological Research, 0-471-56800-7. hal-02850434

HAL Id: hal-02850434
https://hal.inrae.fr/hal-02850434

Submitted on 7 Jun 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Progress in Comparative Endocrinology, pages 193–197
© 1990 Wiley-Liss, Inc.

GROWTH HORMONE AND THYROID HORMONE LEVELS DURING SMOLTING IN DIFFERENT POPULATIONS OF ATLANTIC SALMON

Gilles Boeuf and Pierre-Yves Le Bail

IFREMER, Centre de Brest, Station Ressources Vivantes, BP 70 29263 Plouzané (G.B.) and INRA / physiologie des poissons, campus de Beaulieu, 35042 Rennes cedex, (P.Y.L.B.), France.

The physiological, biochemical, and endocrinological changes occuring at smolting are numerous and have been reviewed frequently (Fontaine, 1975; Boeuf, 1987; Hoar, 1988). Among hormones involved in the parr-smolt transformation (cortisol, PRL, adrenaline,...) thyroid and growth hormones seem to play a major role: thyroxine (T_4) blood plasma surges have been recorded at smolting in Pacific species (Grau *et al.*, 1981; Dickhoff *et al.*, 1982) and in Atlantic salmon (Lindahl *et al.*, 1983; Bouef and Prunet, 1985). Tri-iodothyronine (T_3) peaks can also occur in this last fish (Boeuf *et al.*, 1989; Prunet *et al.*, 1989). Growth hormone (GH) is known to increase sharply before the end of smoltification (Sweeting *et al.*, 1985; Boeuf *et al.*, 1989; Prunet *et al.*, 1989; Young *et al.*, 1989). Evidence for a direct and specific role of thyroid hormones (TH) in seawater adaptability is not yet forthcoming (Boeuf, 1987); with the recent development of specific radioimmunoassay for salmonid growth hormones, (Bolton *et al.*, 1986; P. Le Bail, J. Carragher, J. Sumpter, unpublished), we can now investigate their biological roles. We propose here to review rapidly the possible actions and the inter-relationships between TH and GH during smolting taking also in account, in field endocrinology, the origin of the salmon broodstock.

THYROID HORMONES

From the first studies published in the fifties and reviewed by Fontaine in 1975 we know of the involvement of TH in smolting processes. Studies have shown, in both Pacific and Atlantic species, the occurrence of T_4 surge(s) some weeks to some days before the best seawater adaptability time as indicated by the highest level of gill microsome (Na^+-K^+)-ATPase activity in freshwater fish at the end of the parr-smolt transformation (Folmar and Dickhoff, 1978, 1981; Dickhoff *et al.*, 1982; Sullivan *et al.*, 1983; Boeuf and Prunet, 1985; Virtanen and Soivio, 1985; Boeuf *et al.*, 1989). The work of Grau *et al.* (1981) demonstrated

relationships between T_4 peaks and the lunar cycle in coho and chinook salmon. Such phenomena have subsequently been found in other Pacific species (Yamauchi *et al.*, 1984), but not in species of the genus Salmo (Lin *et al.*, 1985; Boeuf, 1987; Boeuf *et al.*, 1989). In the studies where levels were measured, very often no changes were observed during the smolting cycle in Pacific species; however, Dickhoff *et al.* (1982) encountered two increases, the first in February-March and the second, later. These occur regularly in Atlantic salmon (Boeuf and Prunet, 1985; Boeuf *et al.*, 1989). If they are reared in the same conditions (but in different tanks) numerous batches of fish of the same population exhibit T_3 and T_4 peaks exactly at the same time (Boeuf and Gaignon, 1989). These high TH peaks encountered during smolting are not due to changes in properties of plasma TH binding proteins; a high seasonal correlation appears between free and total hormones (Boeuf *et al.*, 1989b). Thyroxine probably exerts a tissue-specific role at these elevated levels.

After transfer to seawater the T_4 level is unaffected or can decrease (Folmar and Dickhoff, 1981; Dickhoff *et al.*, 1982; Boeuf, 1987; Boeuf *et al.*, 1989b) while T_3 can also decrease (Dickhoff *et al.*, 1982; Boeuf *et al.*, 1989a). Milne and Leatherland (1980) concluded that, if TH could be indirectly affected by the salinity, they did not play a major role in seawater adaptation. Folmar and Dickhoff (1981) found that T_4 just prior to seawater entry influenced survival over six months in coho salmon, but estimated that it had no osmoregulatory role there. Pereira and Adelman (1985) concluded likewise for chinook salmon. More recent results in Atlantic salmon (Boeuf, 1987; Boeuf *et al.*, 1989a,b) showed no correlation between T_3 or T_4 levels and seawater adaptability but do agree with previous studies (Dickhoff *et al.*, 1982; Nagahama *et al.*, 1982; Grau *et al.*, 1985) that osmotic capacities are high after the T_4 surge. The transitory high T_4 level (and possibly T_3) may determine the beginning of acquiring euryhalinity, followed by a long period of seawater tolerance; it is after the drop of T_4, at the highest gill ATPase activity level, that the smolt reaches its maximum capacities of seawater adaptability. Despite this lack of evidence of direct implication of TH in salmonid osmoregulation at the end of the parr-smolt transformation, these hormones play a major role in metabolism, growth, stimulation of silvering, environment memorization, and imprinting, initiation of seawater tolerance, and triggering of migratory behaviour (see the reviews of Boeuf, 1987; Hoar, 1988). To examine this last aspect, we reared in the same hatchery (G. Boeuf, J. Gagnion, P. Le Bail, unpublished data), under the same conditions, three populations of Atlantic salmon originating in short (Namsen in Norway and Elorn in Brittany, <100 km) rivers and in a very long stream (Loire-Allier in France, >900 km). The fish of the two first brookstocks responded "classically" presenting T_3 and T_4 peaks, the latter having occured 2-3 weeks before the highest gill enzyme activity level (third week of April). Salmon of the long stream exhibited T_4 increase one month earlier (beginning of March). It seems that, even when reared in the same conditions, the fish are able to "pre-determine" migration time so that long distance migrants experience these hormonal changes earlier, but both groups finish smoltification in fresh water and are fully preadapted when they reach the ocean.

GROWTH HORMONE

Few studies have been published on GH during salmonid smoltification (Sweeting *et al.*, 1985; Boeuf *et al.*, 1989; Prunet *et al.*, 1989; Young *et al.*, 1989a). In Atlantic salmon GH peak occurs coincident with T_3 increase at smolting (Boeuf *et al.*, 1989a; Prunet *et al.*, 1989). After the surge, 2-3 weeks before the maximum gill ATPase, the GH blood plasma level remains rather high. After transfer to high salinity seawater GH rises sharply within 24 hours, is sustained for 7-10 days and then decreases to levels identical with freshwater fish after two weeks, these changes occuring slightly before, during, and after the best time to contact seawater (Boeuf *et al.*, 1989a).

GH changes more than TH after freshwater-sea water transfer: is this hormone more directly involved in osmoregulation? GH injections or implants can stimulate gill ATPase activity (Richman and Zaugg, 1987; Boeuf *et al.*, in prep.) and improve seawater adaptability (Komourdjian *et al.*, 1976) better than TH (Miwa and Inui, 1983; Saunders *et al.*, 1985; Omeljaniuk and Eales, 1985; Boeuf, unpublished data). The synergistic effect T_3-GH seems very efficient (Miwa and Inui, 1985). GH is also known as being very active on the peripherical mechanism of T_4 deiodination (De Luze and Leloup, 1984), fundamental in TH action and metabolism (Eales, 1985).

In the experiment presented earlier comparing different Atlantic salmon broodstocks in relationship to the length of the original river, GH levels increased much earlier in Loire-Allier salmon than in short river fishes (G. Boeuf, J. Gaignon, P. Le Bail, unpublished data). In addition to the clear GH involvements in growth and osmoregulation in seawater, this molecule also perhaps plays a role in migration.

From all these data, it's clear that thyroid hormones and growth hormone play a major role during salmonid parr-smolt transformation. Smolting salmonids develop in freshwater most of the systems they will need later in sea water. The effective transfer into salt water (or the active migration) would act only as a final stimulus to achieve these processes. GH and TH appear to allow these transformations not only in terms of growth but also in several changes occuring during smoltification.

REFERENCES

Boeuf G. (1987). Contribution à l'étude de l'adaptation à l'eau de mer chez les Poissons Balmonidés–Détermination de critères de smoltification par mesures de l'activité (Na^+K^+)-ATPasique des microsomes de la branchie et es hormones thyroidiennes plasmatiques. Thèse de Doctorat d'Etat, Université de Bretagne Occidentale, 370 pp.

Boeuf G, Prunet P (1985). Measurements of gill (Na-K)-ATPase activity and plasma thyroid hormones during smoltification in Atlantic salmon, *Salmo salar* L. Aquaculture, 45:111-119.

Boeuf G, Gaignon JL (1989a). Effects of rearing conditions on growth and thyroid hormones dueing smolting of Atlantic salmon, *Salmo salar* L. Aquaculture, in press.

Boeuf G, le Bail PY, Prunet P (1989a). Growth hormone and thyroid hormones during Atlantic salmon, *Salmo salar* L, smolting and after transfer to seawater. Aquaculture, in press.

Boeuf G, Uin L-M, Eales JG (1989b). Plasma levels of free and bound thyroid hormones during parr-smolt transformation in Atlantic salmon, *Salmo salar* L. Can J Zoology, in press.

Bolton JP, Takahashi A, Kawauchi H, Kubota I, Hirano T (1986). Development and validation of a salmon growth hormone radioimmunoassay. Gen Comp Endocrinol 62:230-238.

De Luze A, Leloup J (1984). Fish growth hormone enhances peripheral conversion of thyroxine to triiodothyronine in the eel, *Anguilla anguilla* L. Gen Comp Endocrinol, 56:308-312.

Dickhoff WW, Folmar LC, Mighell JL, Mahnken CW (1982). Plasma thyroid hormones during smoltification of yearling and underyearling coho salmon and yearling chinook salmon and steelhead trout. Aquaculture 28:39-48.

Eales JG (1985). The peripheral metabolism of thyroid hormones and regulation of thyroidal status in poikilotherms. Can J Zool 60:304-309.

Folmar LC, Dickhoff WW (1979). Plasma thyroixine and gill Na^+K^+ ATPase changes during seawater acclimatation of coho salmon *Oncorhynchus kisutch*. Comp Biochem Physiol 63(A):329-332.

Folmar LC, Dickhoff WW (1981). Evaluation of some physiological parameters as predictive indices of smoltification. Aquaculture 23:309-324.

Fontaine M (1975). Physiological mechanisms in the migration of marine and amphihaline fish. Advances in Marine Biol 13:241-355.

Grau EG, Dickhoff WW, Nishioka RS, Bern HA, Folmar LC (1981). Lunar phasing of the thyroxine surge preparatory to seaward migration of salmonid fishes. Science 211:607-609.

Grau EG, Fast AW, Nishioka RB, Bern HA, Barclay DK, Katase SA (1985). Variations in thyroid hormone levels and in performance in the seawater challenge test accompanying development in coho salmon raised in Hawaii. Aquaculture 45:121-132.

Hoar WS (1988). The physiology of smolting salmonids. In Hoar WS, Randall DJ (eds): "Fish Physiology, vol XIB," New York: Academic Press, pp 275-343.

Komourdjian MP, Saunders RL, Fenwick JC (1976). The effect of porcine somatropin on growth and survival in seawater of Atlantic salmon, *Salmo salar, parr*. Can J Zool 54:531-535.

Lin RY, Rivas RJ, Nishioka RS, Grau EG, Bern HA (1985). Effects of feeding triiodothyronine (T_3) on thyroxin (T_4) levels in the steelhead trout (*Salmo gairdneri*). Aquaculture 45:133-142.

Lindahl K, Lundquist H, Rydevik M (1983). Plasma thyroxine levels and thyroid gland histology in Baltic salmon (*Salmo salar* L.) during smoltification. Can J Zool 61:1954-1958.

Milne RS, Leatherland JF (1980). Studies onthe relationship between osmotic and ionic regulation and thyroid gland activity in two salmonid fishes *Salmo gairdneri* Richardson and *Oncorhynchus kisutch* Walbaum. J Fish Biol 16(4):349-360.

Miwa S, Inui Y (1983). Effects of thyroxine and thiourea on the parr smolt transformation of amago salmon *Oncorhynchus rhodurus*. Bull Nat Res Inst Aquaculture 4:41-52.

Miwa S, Inui Y (1985). Effects of L. thyroxine and ovine growth hormone on smoltification of amago salmon *Oncorhynchus rhodurus*. Gen Comp Endocrinol 58:436-442.

Nagahama Y, Adachi S, Tashiro F, Grau EG (1982). Some endocrine factors affecting the development of seawater tolerance during the parr-smolt transformation of the amago salmon *Oncorhynchus rhodorus*. Aquaculture 28:81-90.

Omeljaniuk RJ, Eales JG (1985). Immersion of rainbow trout in 3,5,3' triiodo-L-thyronine (T_3): effects on plasma T_3 levels and hepatic nuclear T_3 binding. Gen Comp Endocrinol 58:81-88.

Pereira DL, Adelman IR (1985). Interactions of temperature, size, and photoperiod on growth and smoltification of chinook salmon *Oncorhynchus tshawytscha*. Aquaculture 46:185-192.

Prunet P, Boeuf G, Bolton JB, Young G (1989). Smoltification and seawater adaptation in Atlantic salmon (*Salmo salar* L.): plasma prolactin, growth hormone and thyroid hormones. Gen Comp Endocrinol 74:355-364.

Richman NH, Zaugg WS (1987). Effects of cortisol and growth hormone on osmoregulation in pre and post smoltified coho salmon *Oncorhynchus kisutch*. Gen Comp Endocrinol. 65:189-19.

Saunders RL, McCormick SD, Henderson EB, Eales JG, Johnson CE (1985). The effect of orally administered 3,5,3' triiodo-L-thyronine on growth and salinity tolerance of atlantic salmon *Salmo salar* L. Aquaculture 45:143-156.

Sullivan CV, Dickhoff WW, Brewer SD, Johnson GP (1983). Plasma thyroid hormone concentrations and gill (Na^+K)-ATPase activities in postemergent pink salmon. Trans Am Fish Soc 112:825-829.

Sweeting RM, Wagner GF, McKeown BA (1985). Changes in plasma glucose, amino acid nitrogen, and growth hormone during smoltification and seawater adaptation in coho salmon *Oncorhynchus kisutch*. Aquaculture 45:185-197.

Virtanen E, Soivio A (1985). The patterns of T_3, T_4, cortisol and Na-K ATPase during smoltification of hatchery reared *Salmo salar* and comparison with wild smolts. Aquaculture 45:97-109.

Yamauchi K, Koide N, Adachi S, Nagahama Y (1984). Changes in seawater adaptability and blood thyroxine concentrations during smoltification of the masu salmon *Oncorhynchus masou* and the amago salmon *Oncorhynchus rhodurus*. Aquaculture 42:247-256.

Young G, Bjornsson BT, Prunet P, Lin RJ, Bern HA (1989). Smoltification and seawater adaptation in coho salmon (*Oncorhynchus kisutch*): plasma prolactin, growth hormone, thyroid hormones, and cortisol. Gen Comp Endocrinol 74:335-345.

PROGRESS IN COMPARATIVE ENDOCRINOLOGY

Proceedings of the Eleventh International Symposium on Comparative Endocrinology, Held in Malaga, Spain, May 14–20, 1989

Editors

August Epple
Daniel Baugh Institute of Anatomy
Thomas Jefferson University
Philadelphia, Pennsylvania

Colin G. Scanes
Department of Animal Sciences
Rutgers University
New Brunswick, New Jersey

Milton H. Stetson
School of Life and Health Sciences
University of Delaware
Newark, Delaware

WILEY-LISS

A JOHN WILEY & SONS, INC., PUBLICATION
NEW YORK • CHICHESTER • BRISBANE • TORONTO • SINGAPORE