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Review

CLASSIFICATION OF METHODS FOR THE PREVENTION AND CORRECTION OF INJURIOUS PECKING IN GAME BIRDS AND POULTRY

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ABSTRACT
The fight to control injurious pecking in routine practice in game birds (pheasants, partridges, quails, etc.) or in poultry (chickens, ducks, turkeys, etc.) farming is divided into two basic groups of methods. The first group consists of direct (symptomatic) methods that aim to stop the damaging behaviour, through individual manipulations on the birds, without correcting the predisposing factors. These include beak manipulations (thermal and mechanical beak trimming, the use of special devices such as spectacles, bits, bumpabits, etc.), administration of medications (sedatives, tranquilizers, and repellents), and the identification and isolation of cannibalistic birds for individual treatment. The second group includes indirect (management) methods that address the predisposing factors for IP. These approaches take time to show results and do not stop pecking immediately, but are essential for the long-term prevention of feather pecking and cannibalism. They include adjustments in nutrition, lighting and changes in the spatial parameters of breeding, as well as environmental enrichment. In poultry, the most innovative method to counteract this harmful behaviour include genetic and molecular approaches, through the development of selection programs.

Key words: harmful behaviour, feather pecking, cannibalism, game birds, poultry

INTRODUCTION

Injurious pecking (IP) is a major problem in many game farms (1, 2). Game birds (such as pheasants, grey and chukar partridges, etc.) exhibit severe levels of cannibalism, causing serious tissue damage, often accompanied by haemorrhage and death of large numbers of birds (3, 4). The problem of feather pecking (FP) remains unresolved in poultry farms (5). Most often, gentle (GFP) or severe feather pecking (SFP) is observed mainly in chickens, turkeys, Japanese quail and ducks, causing plumage damage and the appearance of bare areas. (6, 7). In egg-layers, cloacal cannibalism often develops (8). The result of vent pecking is reduced bird growth and reduced egg production (9). There is a detailed classification of the types of damaging behaviour in our previous work (10). The aetiology of the manifestation of harmful behavior is divided into extrinsic factors: nutritional factors, environmental factors (light, temperature, sound and air) and rearing conditions (spatial parameters, type of system and enrichment of rearing conditions) and intrinsic factors (social, gender, age, stress, central nervous, hereditary and immunological) in our previous review (11). To date, there has been no unified classification of the different methodologies for stopping FP and cannibalism in different bird species. The aim of this review is to present in a new way the methods for limiting or controlling the IP in game and domestic birds, by systematizing and summarizing the data – **Table 1.**

I. DIRECT (symptomatic) METHODS to stop damaging behaviour, through individual manipulations on the birds, without correcting the predisposing factors:

1.1. Beak trimming. It is a partial amputation of the beak, with one-third of the upper and lower beaks being removed (12). It is done in two main ways, by infrared or by a heated blade (cauterization) for cutting (2, 13). Beak trimming is a primary method for controlling FP and cannibalism and reducing the damage caused by them (14, 15). Usually in the poultry farming there is beak trimming on the first day

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after hatching and none after that. In game fowl rearing in game farms beak trimming is not a usual practice. In adult birds beak trimming is in use where the number of birds is low, mainly in hobby birds or backyard poultry breeding. In adult birds, beak trimming leads to a rapid reduction in plumage damage (12, 16) because birds perform less SFP, but GFP increases (6, 17). This is a routine practice mainly in egg layers, and in some countries in turkeys and ducks.

Table 1. *Types of methods for correcting IP in game and poultry.*

TYPE	Name	Action / Effect	Species of birds	Industrial farming	Humanity
I. Direct methods	*Beak trimming*	Quick / Long-lasting	game birds and poultry	Yes	NO
	Beak blunting	Quick / Temporary	game birds and poultry	Yes	NO
	Beak devices (spectacles, bits, bumpabits)	Quick / Temporary	mainly in game birds	Yes	NO
	Sedatives and tranquilizers	Quick / Temporary	game birds and poultry	Rare	NO
	Repellents	Quick / Temporary	game birds and poultry	Rare	NO
	Differentiation and separation of birds	Quick / Temporary	game birds and poultry	No	YES
	Individual treatment of injured birds	Medium / Temporary	game birds and poultry	No	YES
II. Indirect methods	*Feeding management*	Medium / Long-lasting	Game birds and poultry	Yes	YES
	Visual-related factors	Quick / Temporary	game birds and poultry	Yes	NO
	Change in spatial parameters	Medium / Long-lasting	game birds and poultry	No	YES
	Enrichment of the environment	Medium / Long-lasting	game birds and poultry	No	YES
III. Genetic methods / Selection programs	*Individual selection*	Slow / Permanent	poultry	Yes	contradictory
	Group selection	Slow / Permanent	poultry		contradictory
	Combined selection	Slow / Permanent	poultry		YES

Legend: *Quick action* - after applying the method, an immediate cessation of IP is observed. *Medium action* - It takes days, weeks, or months for IP to end. *Slow action* - correction of IP is observed in the next generations. *Temporary effect* - after the method is terminated, IP may recur. *Long-lasting effect* - after stopping the method, no subsequent occurrence of IP is observed. *Permanent effect* - FP behaviour is not manifested in the next generations.

Disadvantages: Trimming with a heated blade causes pain and alters the sensitivity and function of the beak (18, 19). There is behavioural and neurological evidence that beak trimming causes both acute and chronic pain (20). Beak trimming can also make normal pecking painful (16). Neuroma formation and long-term changes in feed intake and behaviour indicative of chronic pain may occur (19). When applied at an early age in turkeys and chickens, no neuroma formation is observed (20). Trimming with an infrared blade has been suggested as a more precise and effective method, but there is disagreement about which method is better in terms of animal welfare (13).

1.2 Beak blunting. It is a possible alternative method for reducing levels of damaging behaviour in birds and is carried out by mechanically removing the tip of the beak, without the use of high temperature (7). Beak blunting refers to non-invasive or minimally invasive method where only the tip or sharp point of the beak is dulled, without removing significant tissue. In commercial poultry farming this is made via using of abrasive surfaces in cages or feeders (16). That method raises lower welfare concerns compared to beak trimming (debeaking), which is a more invasive procedure where a portion of the bird's upper (and sometimes lower) beak is permanently removed. The disadvantage is that the effect on behaviour and mortality from FP and cannibalism is relatively small (19, 21).

1.3. Beak devices. Various types of devices/limiters are used that are fixed to the beak of game birds, most commonly used with pheasants to reduce FP and cannibalism (2). They differ in design, function, and the way they affect the bird's behaviour.

- *Beak closure limiters (Beak bits).* They are special plastic or metal unclosed rings that are placed in the birds' nostrils. In pheasants, they are placed at 3 weeks of age and removed, most often immediately before the birds are released into the wild (22) or slaughtered. These beak bits prevent birds from fully closing the upper and lower parts of their beaks, making it impossible to peck and pluck feathers or tissue from another bird (2). The use of beak bits has been observed to have a positive effect on plumage and skin lesions caused by IP in pheasants (22). A type of beak bit with an additional flat front plate, called a 'bumper' acts as a physical barrier to prevent pecking is known as a 'Bumpa bit'.

Disadvantages: An increase in the frequency of head shaking and rubbing has been observed in pheasants, likely due to discomfort caused by the intervention (22). This initial behavioural response to the placement of the beak bits has also been reported in chickens equipped with similar anti-FP devices (21). They also cause inflammation of the nostrils and deformation (crossing) of the beak in some of the observed pheasants, especially after 7 weeks of age (22).

- *Beak devices limiting frontal perception (Blinders).* Another beak device used to reduce cannibalism rates in game birds is the application of so called 'blinders', 'spectacles', or 'peepers' (19-22). These are plastic devices with a different design that are mounted on the bird's beak and block frontal vision (20). It has been proven to reduce FP and cannibalism in pheasants, as well as to prevent egg eating and breaking during the reproductive period (2). Spectacles can improve plumage condition and skin lesions in pheasants, but can cause damage to the nares, or their medial septum (22), which will respectively lead to increased mortality (18).

1.4. Administration of sedatives and tranquilizers. Application of classical sedatives (*Kalium bromatum*, *Natrium bromatum*, *Ammonium bromatum*, *Tinctura valerianae*) does not significantly calm birds exhibiting IP (23). Other tranquilizing psychosedatives also used include: diazepamum (Diazepam, Faustan, Seduxen, Valium, Relanium) at a dose of 0.013–0.03 g/kg; meprobamatum (Meprotanum, Tranquilan, Andaxin) at 0.05 g/kg; promazini hydrochloridum (Propazinum, Sinophenin, Sparine) at 0.005 g/kg; and trifluoperazini hydrochloridum (Triphthazinum, Fluperin, Terluzin, Stelazine) at 0.001 g/kg (23).

1.5. Application of repellents. Spraying birds with sprays or aerosols containing repellents, strong odours and irritants has a temporary effect (special bottled sprays, anise oil, mastic, etc.) (23) – not applicable in industrial poultry production.

1.6. Differentiation and separation of birds exhibiting IP. This avoids causing additional harm to the other birds in the group and also avoids the spread of damaging behaviour through copying (imitating) neighbouring individuals (23) – not applicable in industrial poultry where birds are in large numbers.

1.7 Individual treatment of injured birds. This includes separating the pecked birds and providing conservative and medical treatment for their wounds. Application of wound treatment, including surgical methods, combined with the use of ointments such as Granulin, Granofurin, or a mixture of equal parts iodine tincture and glycerin (23), is not considered effective in combating cannibalism and is not applicable in industrial game and poultry farming.

II. INDIRECT METHODS to stop damaging behaviour by correcting predisposing environmental factors. These factors do not immediately affect IP, but require time to have an effect on bird behaviour. They are of fundamental importance for the fight against FP and cannibalism. The most commonly used in routine practice are:

2.1. *Feeding management* – of fundamental importance.

- *Increasing the protein content and amino acids in food* - discussed in detail in our previous review (11). High-protein diets have a positive effect on plumage and reduce IP in pheasants and partridges (4, 8). Adding protein sources, such as blood meal, liver meal, gelatin, casein, cottonseed meal, soybean meal, and others to the basic ration reduces the incidence of FP and cannibalism. (24). A tenfold increase in the daily intake of any of the aromatic amino acids (tryptophan, phenylalanine, or tyrosine) resulted in a significant decrease in IP in birds (5). After a two-fold increase in arginine in the feed of male pheasants, partridges and roosters, their cannibalism ceases (25).

- *Adding fibre content to diet*. Pheasants fed green clover and beech branches as a source of roughage significantly reduced FP and cannibalism compared to the control group (3, 26). Feeding birds carrots, corn and barley-pea silage as a source of roughage reduces FP and lowers mortality from cannibalism (27). Roughage significantly reduces pH in the cecum, resulting in a higher rate of fermentation there (4), and because of the large particles in it, it improves the strength of the gizzard (9).

2.2. Visual-related factors. Visual impairment through the use of low light intensity (1-3 lx or less), coloured contact lenses, lighting duration or genetically blind birds, have been used successfully to control cannibalism and FP (14, 17). However, they strongly affect the well-being and normal physiology of birds and are not recommended in the routine fight against IP (7, 28).

- *Lowered light intensity* is the most commonly used method in this group. Its disadvantages are related to disturbances in the anatomy and function of the eyes (7, 29). The thickness of the choroid increases during the dark part of the day, while the axial length of the eye increases during the light part. Thus, the low light intensity during the day causes a disproportionate development of the visual apparatus of birds (30). In addition, the ability to focus is affected by light (29). Other consequences of low light intensity are reduced bird activity and movements between perches (28). Low physical activity is also associated with osteopenia and a high risk of bone fractures (14). Furthermore, due to the difficulty of visual perception, birds compensatorily increase stereotypical GFP, which is highly undesirable (4, 8).

2.3. Improving raising conditions: Include changes in spatial parameters (density of raising, size of the group and usage of free space) and environmental enrichment (presence of litter, perches, type of drinkers and feeders, and aerated concrete (breeze) blocks (6, 31).

- *Spatial parameters*: the main factor for the manifestation of cannibalism (11). After reducing the density of pheasant breeding, suppression of cannibalism behaviour was observed (1, 3). Even smaller group size (number of birds in the flock) leads to a decrease in the incidence of IP in birds (32). On the other hand, more free space or outdoor time greatly reduces damaging behaviour in birds compared to control groups (31, 33). In practice, however, the best effect is achieved when combining all three spatial parameters simultaneously. Reducing density and group size in combination with usage of free space significantly improves plumage condition and reduces the incidence of skin lesions in pheasants and partridges (34).

- *Enrichment of the environment*: Using several types of feeders and drinkers (7) or scattering food on the ground to redirect birds' attention reduces damaging behaviour (35). Enriching the environment by adding litter (substrate) for hen roosts greatly reduces SFP in them. (9, 36). The use of perches, as in poultry (6, 37), also in pheasants and partridges (3), helps to improve the spatial distribution of birds on the premises and leads to a reduction in cannibalism. Enriching the environment by placing aerated breeze blocks reduces IP in birds (9).

III. GENETIC AND MOLECULAR APPROACHES (Selection programs): Individual selection (38, 39) or group selection (15, 40) is used in different lines of hens against FP and cannibalism behaviour (7, 14).

3.1. Individual selection. It determines whether or not FP is observed in individual birds (38). Individual selection leads to a significant difference in hen behaviour between high and low IP-prone lines (40). The negative aspect of this type of selection is that it can lead to the selection of undesirable behavioural traits, such as FP and cannibalism, as these traits are not expressed in individually housed birds (39).

3.2. Group selection. An alternative to individual selection is group selection, which attempts to avoid selecting for undesirable behaviours by taking into account the interaction of the bird and group members and vice versa (41-, 2). Group selection methods are effective in reducing mortality from IP in laying hens (40, 42). Identifying behavioural and physiological characteristics, such as fear, that have changed after group selection against mortality may help explain why some hens are more prone to developing FP and cannibalistic behaviour than others (15).

3.3. Program genetics (combined selection). Alternative statistical models from the field of evolutionary genetics are available and allow the construction of new methods for selecting groups of birds against undesirable behaviour (42, 43). Based on old developments (40), new methods for schematic selection are being built (42), where information about the candidate for selection (individually placed) is combined with data from its relatives placed in family groups (15, 43).

CONCLUSIONS

Direct methods do not solve the problem of IP in game birds, because after stopping the measures, a recurrence of the damaging behaviour is observed. In addition, they lead to subsequent complications in the birds. They do not comply with European standards for animal welfare and humane treatment.

Indirect methods, if not integrated into the farm's management program, have a slower effect. However, they directly address the predisposing factors for the occurrence of IP in domestic and game birds, offering a long-term solution to the problem. They improve the quality of life and welfare of game birds and poultry.

Individual and group selection of bird breed lines are unpredictable, because correcting one unfavourable behavioural trait can lead to the creation of another. They are of a controversial nature regarding the humane treatment of birds' undesirable behaviour. Combined selection focuses not only on one trait, but on many, which benefits productivity and welfare.

REFERENCES

1. Draycott, R.A.H., M.I.A. Woodburn, J.P. Carroll and R.B. Sage, Effects of spring supplementary feeding on population density and breeding success of released pheasants *Phasianus colchicus* in Britain. *Wildl Biological*, 11:177-182, 2005.
2. Hrabcakova, P., I. Bedanova, E. Voslarova, V. Pistekova and V. Vecerek, Evaluation of tonic immobility in common pheasant hens kept in different housing systems during laying period. *Archiv fur Tierzucht*, 55:626-632, 2012.
3. Kjaer, J.B., Effects of stocking density and group size on the condition of the skin and feathers of pheasant chicks. *Veterinary Record*, 154:556-558, 2004.
4. Van Krimpen, M.M., R.P. Kwakkel, B.F.J. Reuvekamp, C.M.C. Van Der Peet-Schwering, L.A. Den Hartog & M.W.A. Verstegen, Impact of feeding management on feather pecking in laying hens. *Worlds Poultry Science Journal*, 61:663–685, 2005.
5. Birkl, P., L. Frankeb, T. Bas Rodenburgc, E. Ellend and A. Harlander-Matauscheka, A role for plasma aromatic amino acids in injurious pecking behavior in laying hens. *Physiology & Behavior*, 175:88–96, 2017.
6. Gilani, A.M., T.G. Knowles and C.J. Nicol, The effect of rearing environment on feather pecking in young and adult laying hens. *Applied Animal Behaviour Science*, 148:54-63, 2013.
7. Nicol C.J., M. Bestman, A.M. Gilani, E.N. de Haas, I.C. de Jong, S.L. Lambton, J.P. Wagenaar, C.A. Weeks and T.B. Rodenburg, The prevention and control of feather pecking: application to commercial systems. *World's Poultry Science Journal*, 69:775-788, 2013.
8. Sedlackova, M., B. Bilcik and L. Kostal, Feather pecking in laying hens: Environmental and endogenous factors. *Acta Veterinaria Brno*, 73:521-531, 2004.
9. de Haas, E.N., J.E. Bolhuis, I.C. de Jong, B. Kemp, A.M. Janczac and T.B. Rodenburg, Predicting feather damage in laying hens during the laying period. Is it the past or is it the present? *Applied Animal Behaviour Science*, 160:75-85, 2014
10. Nikolov, S. and D. Kanakov, Types and clinical presentation of damaging behaviour - feather pecking and cannibalism in birds, *Bulgarian Journal of Veterinary Medicine*, 25:3, 2022, 349-358, 2022.
11. Nikolov, S. and D. Kanakov, Influencing factors leading to damaging behavior - feather pecking and cannibalism in game birds. *Trakia Journal of Sciences*, 18:4, 377-387, 2020.
12. Staack, M., B. Gruber, C. Keppler, K. Zaludik, K. Niebuhr and U. Knierim, Importance of the rearing period for laying hens in alternative systems. *Deutsche Tierarztliche Wochenschrift*, 114:86–90, 2007.
13. Dennis, R.L., A.G. Fahey and H.W. Cheng, Infrared beak treatment method compared with conventional hot-blade trimming in laying hens. *Poultry Science*, 88:38-43, 2009.
14. Cloutier, S., R.C. Newberry, C.T. Foster and K.M. Girsberger, Does pecking at inanimate stimuli predict cannibalistic behaviour in domestic fowl? *Applied Animal Behaviour Science*, 66:119–133, 2000.
15. Bolhuis, J.E., E.D. Ellen, C.G. Van Reenen, J. De Groot, J.T. Napel, R.E. Koopmanschap, G.D.V. Reilingh, K.A. Uitdehaag, B. Kemp and T.B. Rodenburg, Effects of genetic group selection against

mortality on behavior and peripheral serotonin in domestic laying hens with trimmed and intact beaks. *Physiology & Behavior*, 97:470–475, 2009.
16. Lambton, S.L., C.J. Nicol, M. Friel, D.C.J. Main, J.L. McKinstry, C.M. Sherwin, J. Walton and C.A. Weeks, A bespoke management package can reduce the levels of injurious pecking in loose housed laying hen flocks. *Veterinary Record*, 172:423-430, 2013.
17. Lambton, S.L., T.G. Knowles, C. Yorke and C.J. Nicol, The risk factors affecting the development of gentle and SFP in loose housed laying hens. *Applied Animal Behaviour Science*, 123:32–42, 2010.
18. Freire, R., P.C. Glatz and G. Hinch, Self-administration of an analgesic does not alleviate pain in beak-trimmed chickens. *Asian-Australasian Journal Animal Science*, 21:443-448, 2008.
19. Freire, R., M.A., Eastwood and M. Joyce, Minor beak trimming in chickens leads to loss of mechanoreception and magnetoreception. *Journal Animal Science*, 89:1201-1206, 2011.
20. Jongman, E.C., P.C. Glatz and J.L. Barnett, Changes in behaviour of laying hens following beak trimming at hatch and re-trimming at 14 weeks. *Asian-Australasian journal of Animal Sciences*, 21:291–298, 2008.
21. Van de Weerd, H.A. and A. Elson, Rearing factors that influence the propensity for injurious feather pecking in laying hens. *World's Poultry Science Journal*, 62:654-664, 2006.
22. Butler, D.A. and C. Davis, Effects of plastic bits on the condition and behaviour of captive-reared pheasants. *Veterinary Record*, 166:398-401, 2010.
23. Markarian, M., Diseases of birds and avian embryos, BG, 183-185, 1998.
24. Schaible, P.J., J.A. Davidson and S.L. Bandemer, Cannibalism and feather picking in chicks as influenced by certain changes in a specific ration. *Poultry Science*, 26:651–656, 1947.
25. Madsen, H., On feather picking and cannibalism in pheasant and partridge chicks, particularly in relation to the amino acid arginine. *Acta Veterinaria Scandinavica*, 7:272-287, 1966.
26. Hoffmeyer, I., Feather pecking in pheasants - an ethological approach to the problem. *Danish Review of Game Biology*, 6:1–36, 1969.
27. Steenfeldt, S., R.M. Engberg and J.B. Kjaer, Feeding roughage to laying hens affects egg production, gastro-intestinal parameters and mortality. In *Proceedings of the 13th European symposium on poultry nutrition.*, Blankenbergen, 2001.
28. Taylor, P.E., G.B. Scott and P. Rose, The ability of domestic hens to jump between horizontal perches: effects of light intensity and perch colour. *Applied Animal Behaviour Science*, 83:99-108. 2003.
29. Prescott, N.B., C.M. Wathes and J.R. Jarvis, Light, vision and the welfare of poultry. *Animal Welfare*, 12:269–288, 2003.
30. Nickla, D.L., C.F. Wildsoet and D. Troilo, Endogenous rhythms in axial length and choroidal thickness in chicks: Implications for ocular growth regulation. *Investigative Ophthalmology & Visual Science*, 42:584-588, 2001.
31. Lambton, S.L., T.G. Knowles, C. Yorke and C.J. Nicol, The risk factors affecting the development of vent pecking and cannibalism in free-range and organic laying hens. *Animal Welfare*, 24:101-111, 2015.
32. Estevez, I., I.L. Andersen and E. Nævdal, Group size, density and social dynamics in farm animals. *Applied Animal Behaviour Science*, 103:185–204, 2007.
33. Daigle, C.L., Chapter 11 - Controlling Feather Pecking and Cannibalism in Egg Laying Flocks. In: *Patricia Hester (ed.) Egg Innovations and Strategies for Improvements*. London, UK: Academic Press., 111-121, 2017.
34. Kjaer, J.B. and P.F. Johnsen, Effect of stocking density/group size and environmental enrichment on feather pecking and plumage condition in pheasants (*Phasianus colchicus*) and partridges (*Perdix perdix*). *Proceedings of the 34th International Congress of the ISAE*. Florianopolis, Brazil, 49, 2000.
35. Blokhuis, H.J. and J.W. Van Der Haar, Effects of pecking incentives during rearing on feather pecking of laying hens. *British Poultry Science*, 33:17–24, 1992.
36. Dixon, L.M. and I.J.H. Duncan, Changes in substrate access did not affect early feather-pecking behavior in two strains of laying hen chicks. *Journal of Applied Animal Welfare Science*, 13:1-14, 2010.
37. Knierim, U., M. Staack, B. Gruber, C. Keppler, K. Zaludik and K. Niebuhr, Risk factors for feather pecking in organic

laying hens-starting points for prevention in the housing environment. *16th IFOAM Organic World Congress*, Modena, Italy, 2008.

38. Kjaer, J.B., P. Sørensen and G. Su, Divergent selection on feather pecking behaviour in laying hens (*Gallus gallus domesticus*). *Applied Animal Behaviour Science*, 71:229–239, 2001.
39. Rodenburg, T.B., F.A.M. Tuyttens, K. De Reu, L. Herman, J. Zoons and B. Sonck, Welfare assessment of laying hens in furnished cages and non-cage systems: an on-farm comparison. *Animal Welfare*, 17:363-373, 2008.
40. Muir, W.M., Incorporation of competitive effects in forest tree or animal breeding programs. *Genetic*, 170:1247–59, 2005.
41. Ellen E.D., J. Visscher, J.A.M. Van Arendonk and P. Bijma, Survival of laying hens: Genetic parameters for direct and associative effects in three purebred layer lines. *Poultry Science*, 87:233–239, 2008.
42. Ellen, E.D., W.M. Muir and P. Bijma, Genetic improvement of traits affected by interactions among individuals: sib selection schemes. *Genetics*, 176:489–499, 2007.
43. Rodenburg, T.B., K.A. Uitdehaag, E.D. Ellen and J. Komen, The effects of selection on low mortality and brooding by a mother hen on open-field response, feather pecking and cannibalism in laying hens. *Animal Welfare*, 18:427-432, 2009.